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Engineering Development Tests Airdrop Controlled Exit System (ACES)

by Walter L. Black

AAI CORPORATION
COCKEYSVILLE, MARYLAND

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AERIAL DELIVERY	AIRDROP CONTROLLED EXIT SYSTEM (ACES)
RECOVERY PARACHUTES	TELEMETERING DATA

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A series of engineering development tests of the Airdrop Controlled Exit System (ACES) was conducted at the Army's Yuma Proving Ground, Arizona. The concept involves connecting individual platform assemblies so that they are extracted from the aircraft in tandem and recovered as a unit with a set of recovery parachutes. The purpose is to avoid the dispersion of the equipment on the drop zone that occurs when performing individual platform airdrops.

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20. ABSTRACT (Continued)

Fourteen tests were performed on ACES assemblies of various configurations. The equipment performed in a generally satisfactory manner. Telemetered data generated by on board instrumentation provided loads at various locations plus motion of the platforms relative to one another. Parachute performance, system trajectories, and motion of the assemblies was monitored by theodolite and motion picture cameras. The test data has been reduced and analyzed and arranged for presentation. Reproductions of the raw telemetered data is included in the report.

PREFACE

Engineering development tests on the Airdrop Controlled Exit System (ACES) were conducted by the US Army Test and Evaluation Command at their Yuma Proving Ground, Arizona. The ACES program is sponsored by the US Army Natick Research and Development Laboratories. Its objective is the development of an airdrop system that will significantly reduce extraction time and control the dispersion of heavy airdropped material on the drop zone.

The AAI Corporation, Cockeysville, Maryland, participated in the test program by developing and manufacturing the system hardware and furnishing engineering assistance during the tests. The US Air Force Aeronautical Systems Division (ASD), WPAFB and the US Air Force Military Airlift Command (MAC) developed aircrew procedures, provided technical advice, and monitored aircraft safety provisions. The data acquired by the Army test unit was furnished to the AAI Corporation for evaluation and preparation of this report.

The program was performed during the period from October 79 through April 80 under the direction of George Chakoian of US Army Natick Research and Development Laboratories under project no. 1G263218D266 and contract DAAK60-77-C-0076.

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I. INTRODUCTION

The US Army Natick Research and Development Laboratories, as part of a continuing program, sponsored an Advanced Development investigation to determine the best method of reducing extraction time and controlling the dispersion of heavy airdropped material on the drop zone. The AAI Corporation contributed to these investigations by performing conceptual, design, fabrication, and laboratory test services that defined a system that has been designated the Airdrop Controlled Exit System (ACES).

The concept involves connecting individual platform assemblies so that they are extracted from the aircraft in tandem and recovered as a unit with a set of recovery parachutes. In current operations each platform is individually extracted and recovered resulting in a large dispersion of equipment and material on the drop zone.

The investigations included an Engineering Design Test (EDT) program to obtain data on the ACES concept under operational conditions. Prototype system hardware and engineering assistance during these tests were furnished by the AAI Corporation. The tests were conducted by the US Army Test and Evaluation Command at their Yuma Proving Ground, Arizona. The test data was acquired and processed and furnished to the AAI Corporation for evaluation. This report has been prepared to present the results of these evaluations.

II. DESCRIPTION OF EQUIPMENT

A. Platform Modifications

The ACES system has been adapted to the 12, 16 and 20-foot standard metric platforms. The structures of these platforms have been altered by adding a welded truss type structure to the side rails to increase their moment carrying capacities. This reinforcing structure added to a coupled pair of 12-foot platforms is shown in Figure 1. The side rails of each platform have also been altered by adding reinforcing bars to which the truss assemblies are attached. These reinforcing bars have been extended beyond the normal length of the platform and arranged to create a hinge line at which the adjoining platforms are connected. This is illustrated in Figure 2.

The truss assemblies require lateral restraint. This is accomplished through the use of lateral braces at the ends of the platforms as shown in Figure 3. A fitting is added to the platform for attachment of the lower end of this brace. These fittings are mounted in existing holes in the platforms.

Platform extraction is employed in the ACES system; i.e. the extraction parachute is attached to the platform rather than the load. Reinforcement bars are added inside the platform and a bracket is provided that allows two degrees of rotational freedom for the standard 35,000-pound force-transfer coupler. The bracket with the coupler installed is shown in Figure 4. This coupler is used to transfer the pull of the extraction parachutes to the deployment bags of the recovery parachutes and cause these parachutes to deploy. Timing of this transfer is accomplished with a release mechanism that is installed along the left hand rail of one of the platforms (usually on the aft platform). A special fitting is provided to adapt this release mechanism to the metric platform (see Figure 5). This release mechanism and the load transfer coupler are connected through a push-pull cable. The arm being manually restrained in the illustration rests on top of the dual rail structure when installed in the aircraft. This restraint ends when this arm clears the end of the ramp, and the arm rotates counterclockwise about 100 degrees causing the 35,000-pound load-transfer coupler to release the extraction parachute and transfer its pull to the recovery parachutes deployment bags.

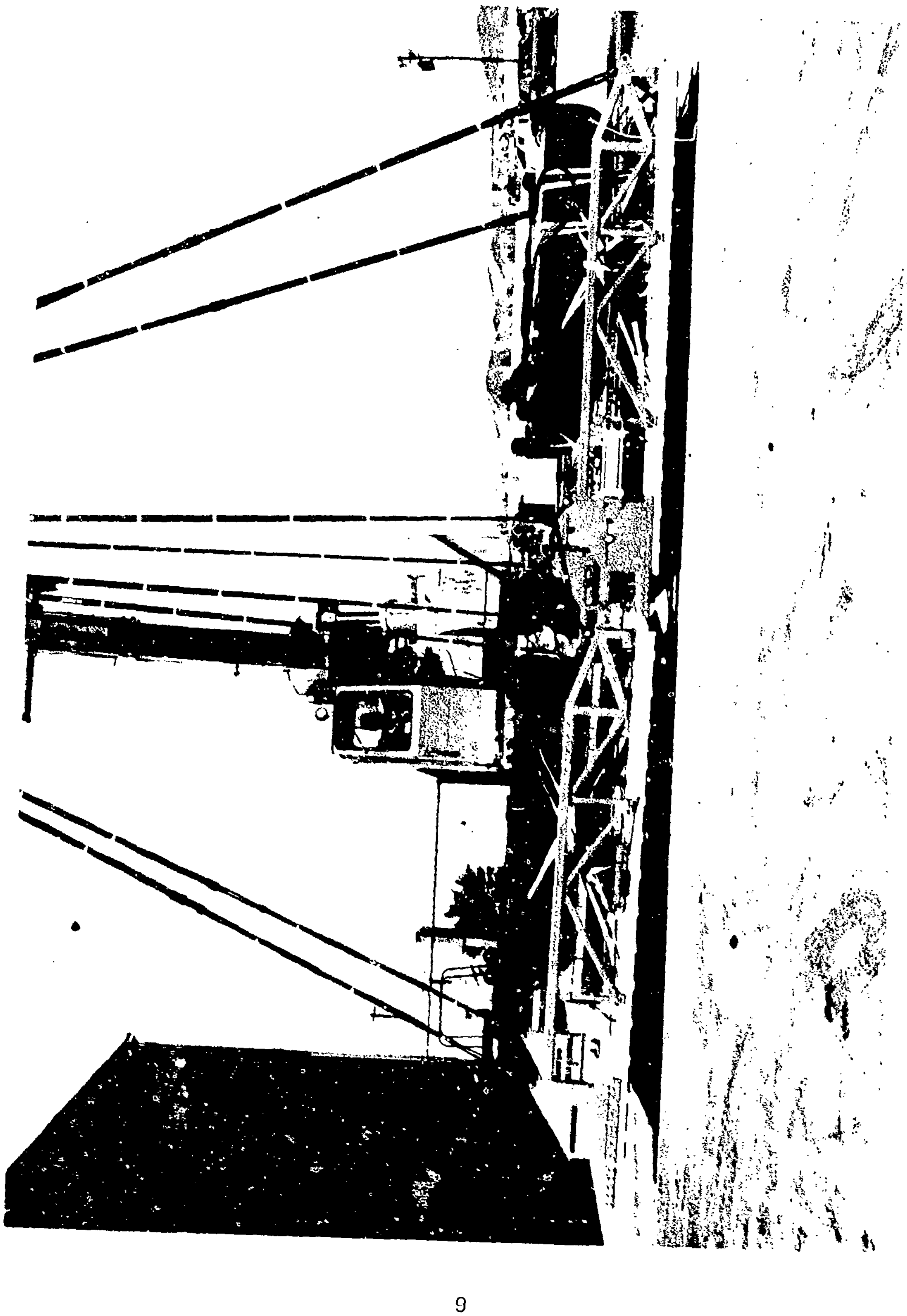


Figure 1. View of Truss Reinforcing Structures

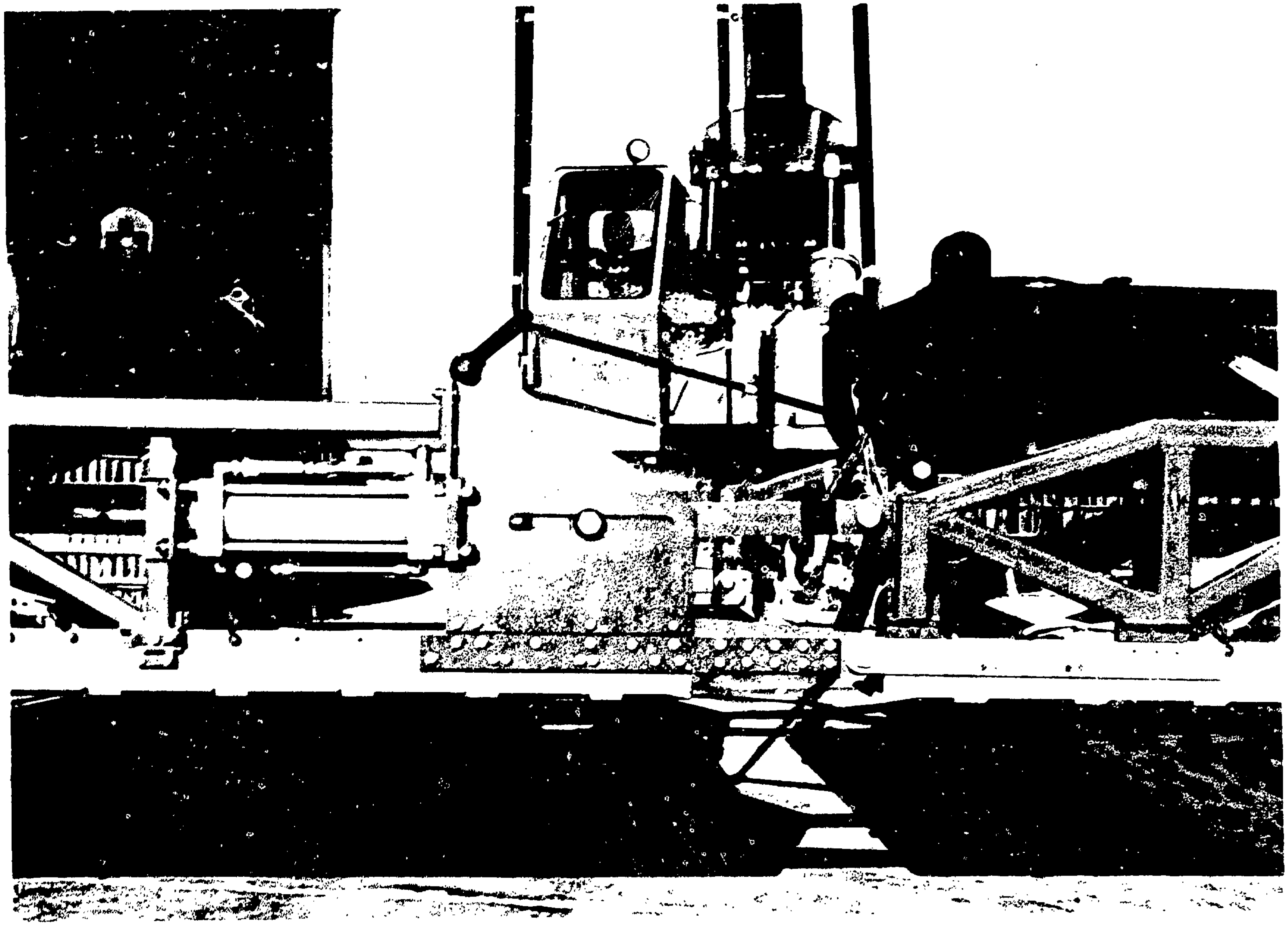
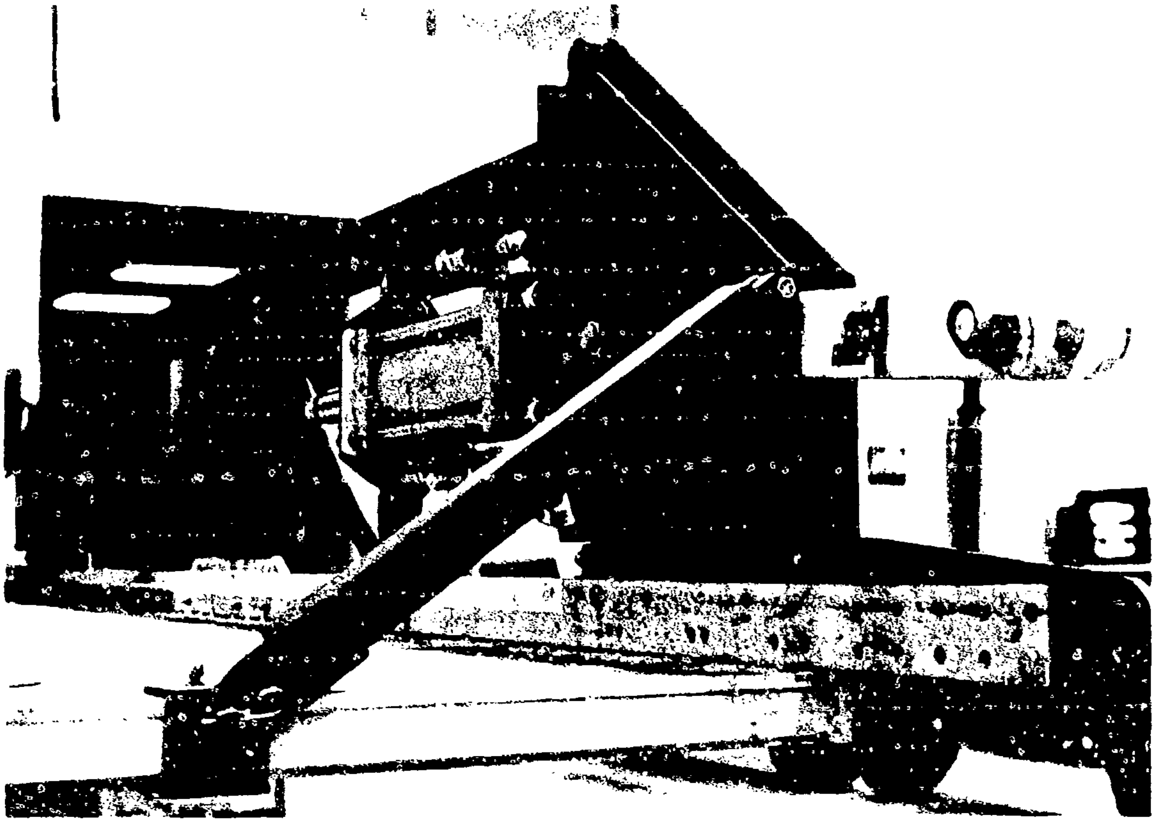
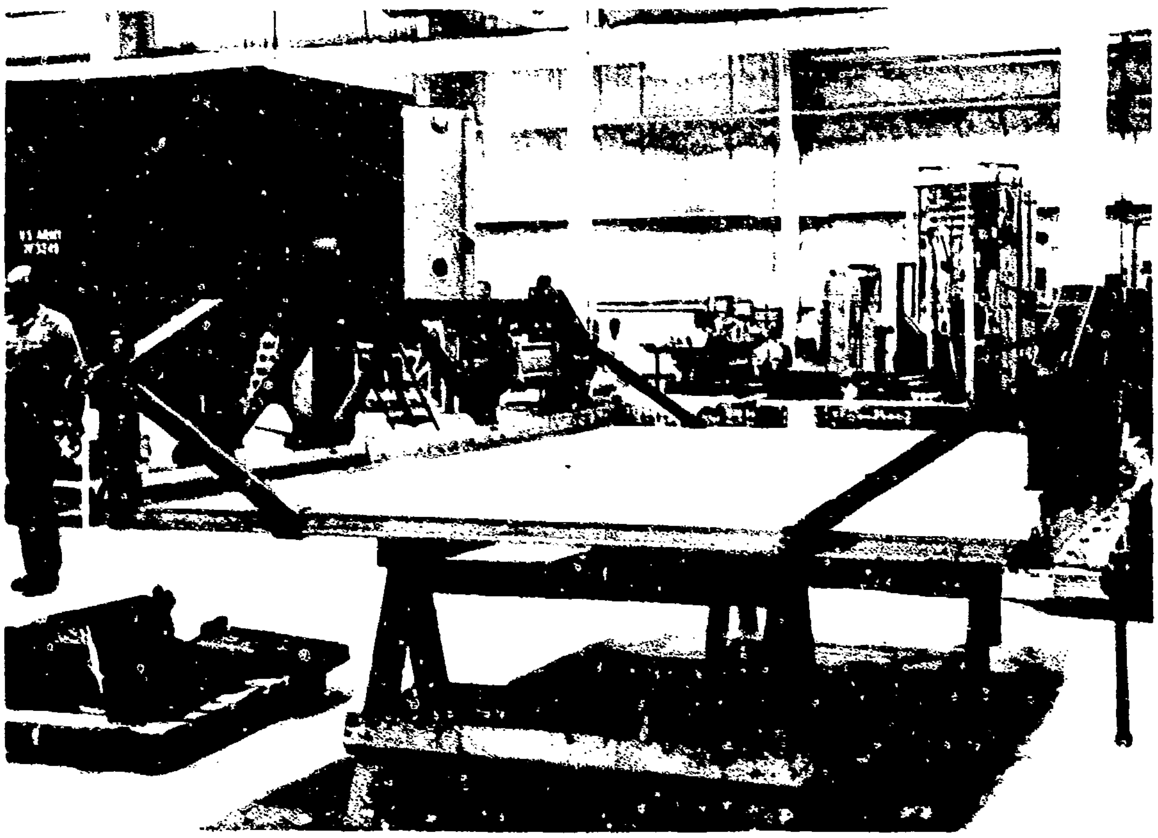


Figure 2. Arrangement of Components at Hinge Line



a. View of Lateral Restraint Braces



b. Details of Restraint Brace

Figure 3. View of Truss Lateral Restraint Braces

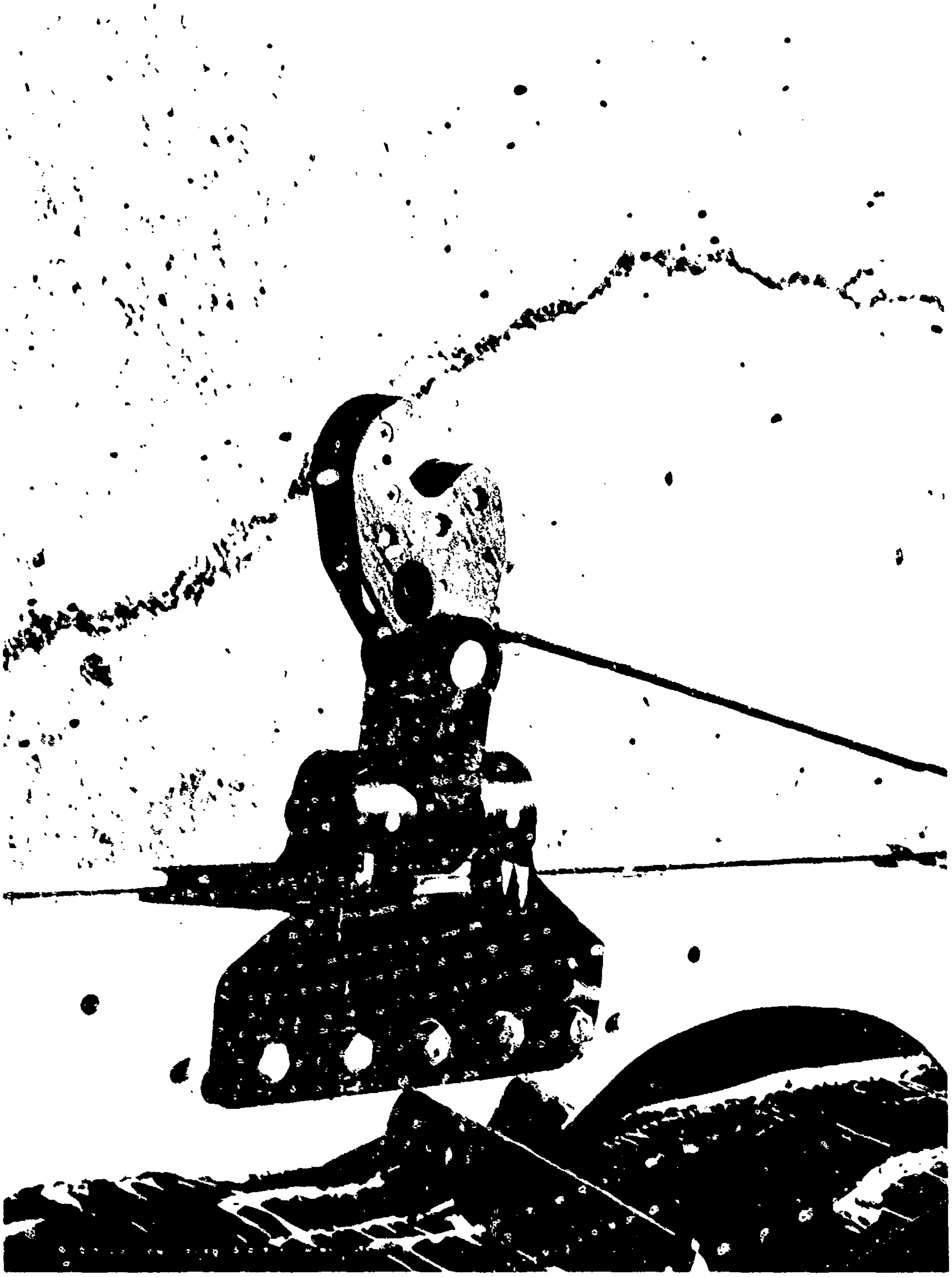


Figure 4. View of 35,000-Pound Extraction Force-Transfer Coupler and Mounting Bracket

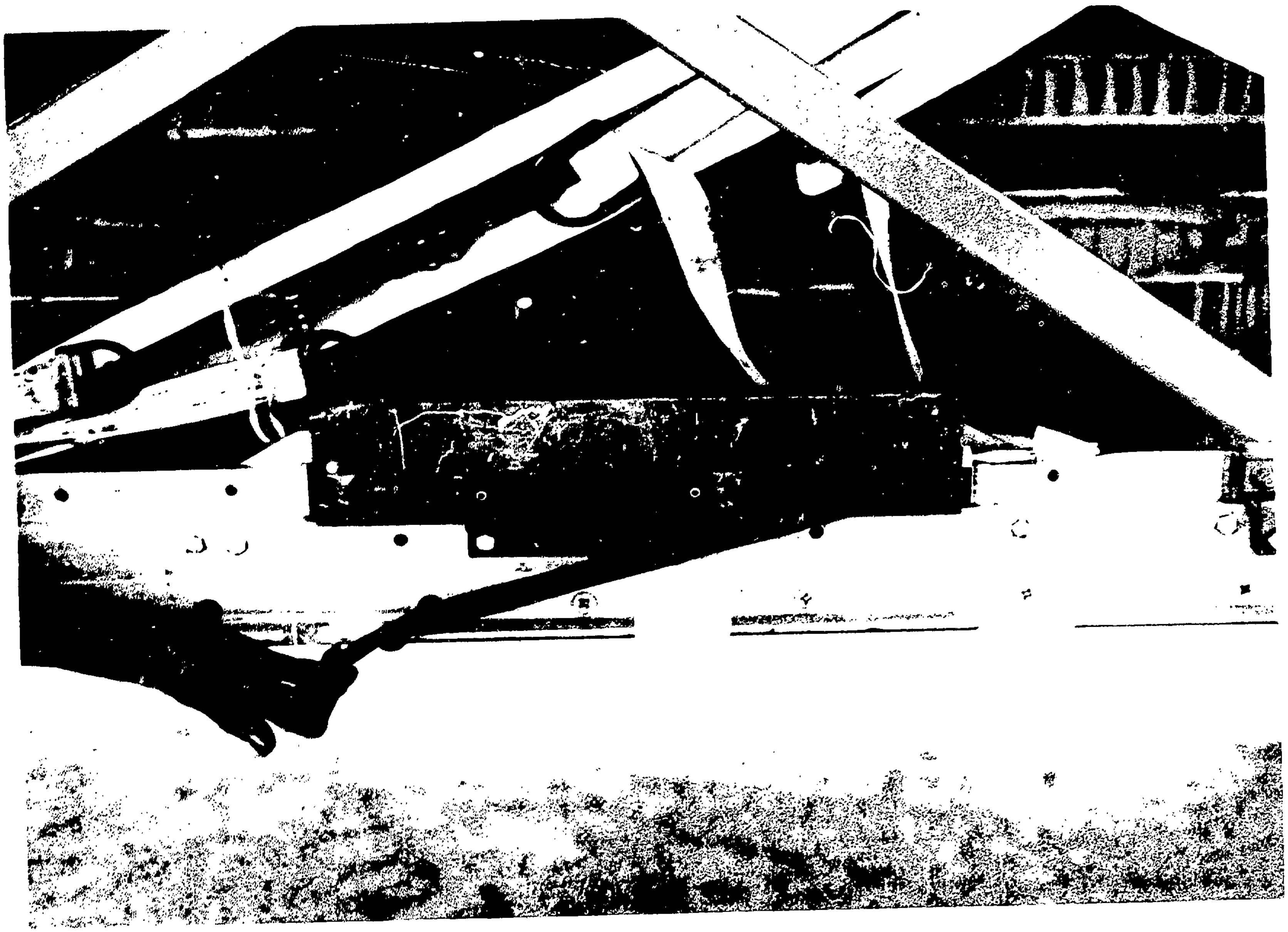


Figure 5. View of Release Mechanism for 35,000-Pound Force-Transfer Coupler

B. Hinge Line Controls

The ability of the ACES system to function properly is dependent upon control of platform rotation about the hinge line that is created when a set of platforms is coupled. The hinge line is located where the bottom rail extensions are joined by a set of 1¼-inch diameter bolts. This is shown clearly in Figure 2. Twelve inches above these rail extensions is a second bar designated the "compression link" which is attached to the truss at one end and to the hydraulic cylinder through a fitting at the other end. A hydraulic cylinder equipped with a set of two lines with a valve in each line is shown in Figure 2. This arrangement allows $\pm$ 30 degrees of rotation about the hinge line. The cylinder has a rod in both ends so that oil displaced in one end of the cylinder can flow into the other end of the cylinder.

The lower line on the hydraulic cylinder is a "by-pass" line and contains a needle valve which can be opened to activate the by-pass during installation and drop preparation. For operation, this by-pass is deactivated by closing the needle valve forcing the oil to flow through the upper line. The upper line contains a check valve that permits free flow of oil during negative rotation, (tip-off rotation), but during rotation in the opposite or positive direction, the valve closes forcing the oil to pass through an orifice. This orifice has been sized to limit the rate of rotation about the hinge line. In operation, the lead platform off the ramp is allowed to rotate freely in the "tip-off" or negative direction. This rotation is quickly arrested by the airloads on the platform, and rotation in the opposite or positive direction begins. Positive rotation, however, is constrained to a small rate by the hydraulic cylinder, for in this direction the oil must flow through the metering orifice. Rotation in this direction is delayed sufficiently to allow full deployment of the recovery parachutes before a large positive rotation angle is reached. Once the recovery parachutes are deployed, they acquire control of the system and maintain alignment of the platforms for touchdown. A view of a two-platform assembly in touchdown condition is shown in Figure 6. A view of a three-platform assembly in similar condition is shown in Figure 7.

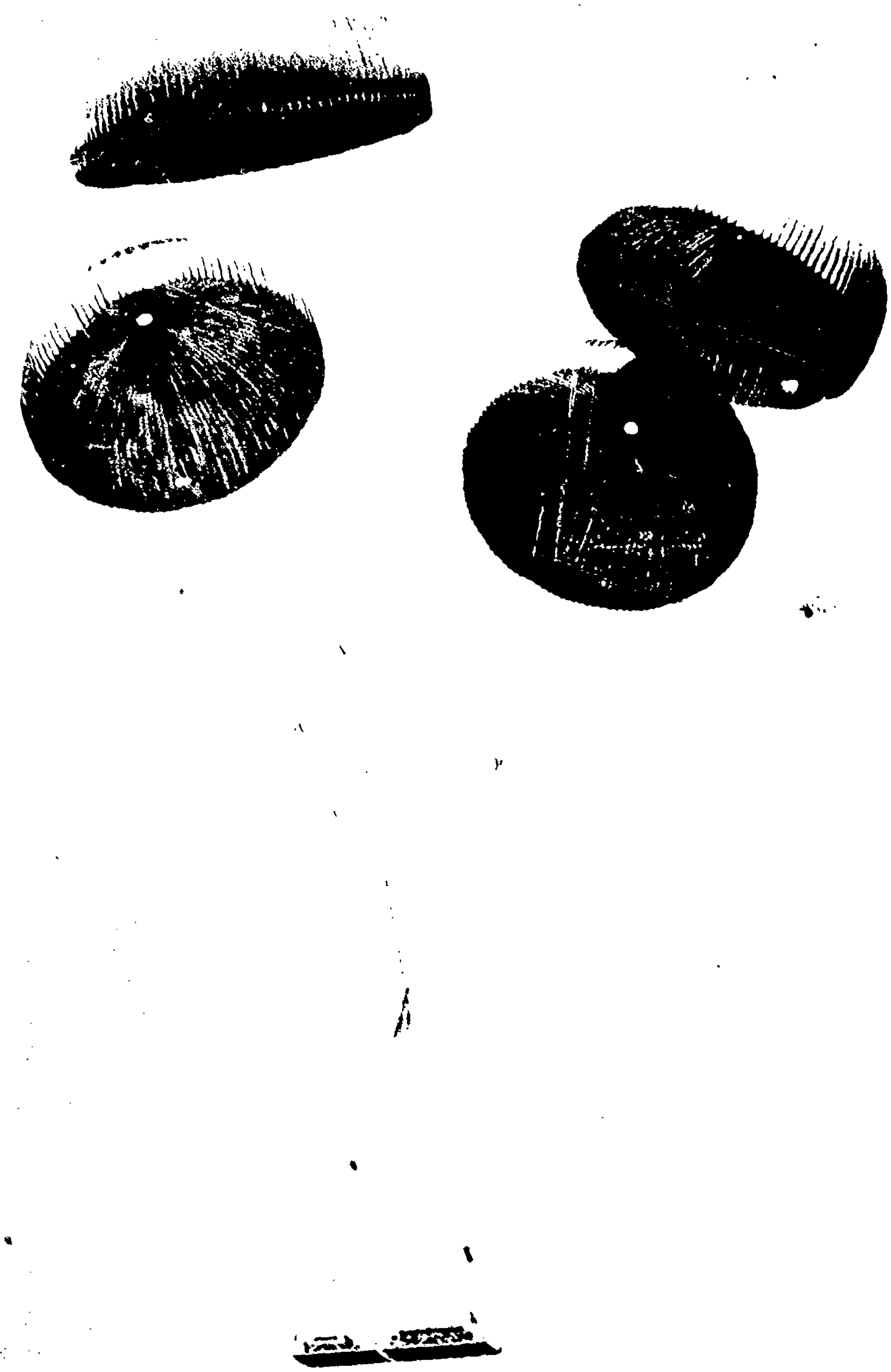


Figure 6. View of Two-Platform Configuration in Touchdown Condition

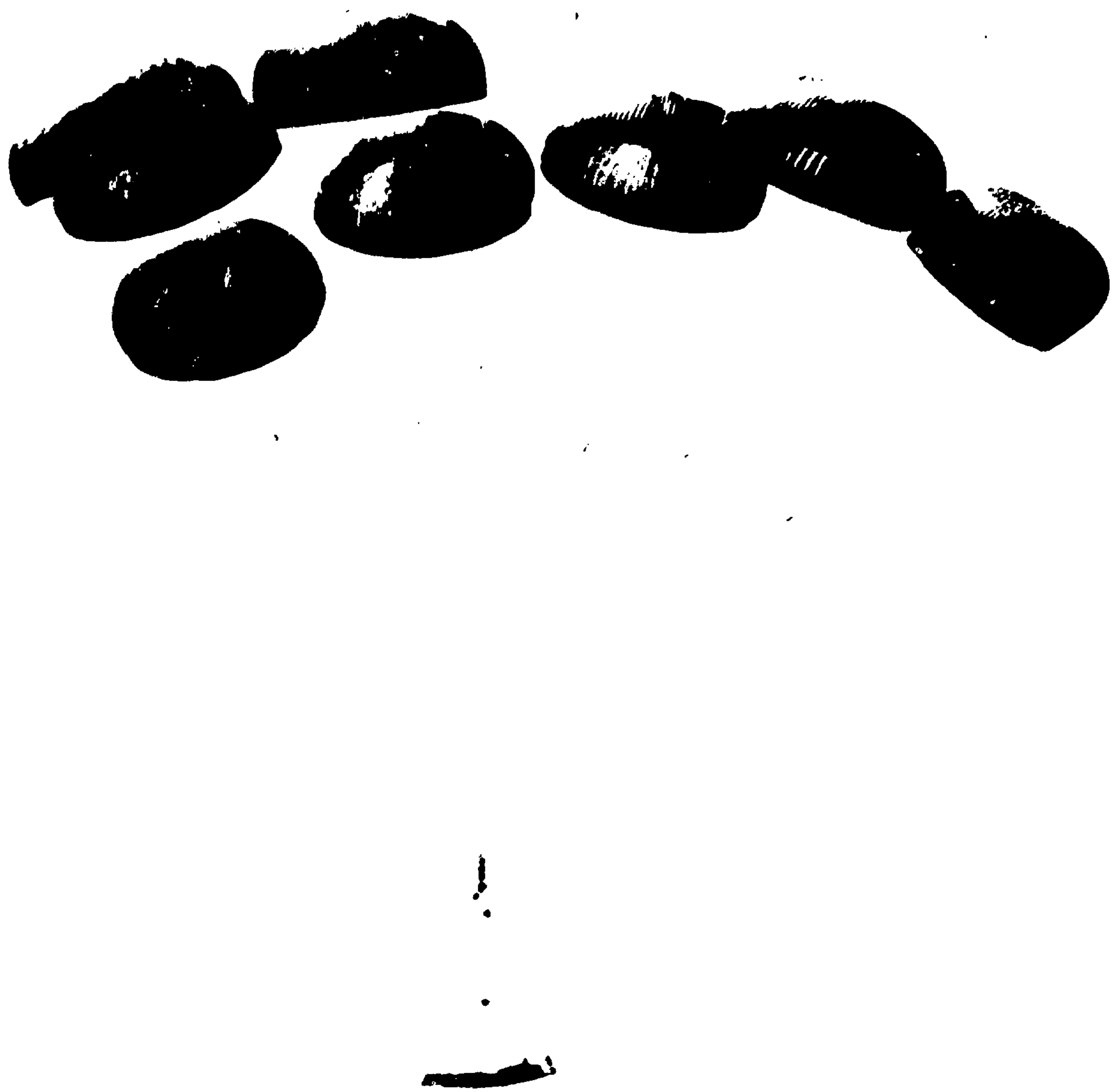


Figure 7. View of Three-Platform Configuration in Touchdown Condition

C. Rigging and Derigging Procedures

Loads are rigged in the ACES system using the same procedures employed in rigging an individual airdrop load. Provisions have been made in the rail reinforcement bars for installation of the hold down devices. A view of test tubs rigged for a test drop is shown in Figure 8.

Derigging is accomplished using current procedures. Provisions have been made, however, to aid the derigging task, if necessary, by rotating the truss assemblies outward or away from the load. Hinge provisions have been incorporated in the truss for this purpose. To employ this feature, the end braces must be disconnected and a number of bolts along the rail removed. It is expected that this procedure will be employed in emergencies where the load may have shifted and is resting against a truss, or the load is extra wide and cannot be removed without folding the rails.

D. Suspension System

The ACES system employs a platform suspended suspension system; i.e., the suspension lines are attached to the platform rather than the load. Provisions have been made in the truss structure for attaching the suspension lines. This is clearly illustrated in Figure 8.

The ACES suspension system is unique in two respects. First, additional suspension lines are required, and second, they are considerably longer than in individual airdrop assemblies. The suspension lines have been designed so that the confluence point is about 60 feet above the load. The purpose of this is to enable the use of suspension lines of approximately the same length regardless of the combination of platform lengths in the assembly and the position of the composite center of gravity. The 60-foot distance to the confluence point allows the attitude of the load at touchdown to be within acceptable limits regardless of where the center of gravity is located. A view of a suspended two-platform assembly is shown in Figure 9. A similar view of a three-platform assembly is shown in Figure 10.

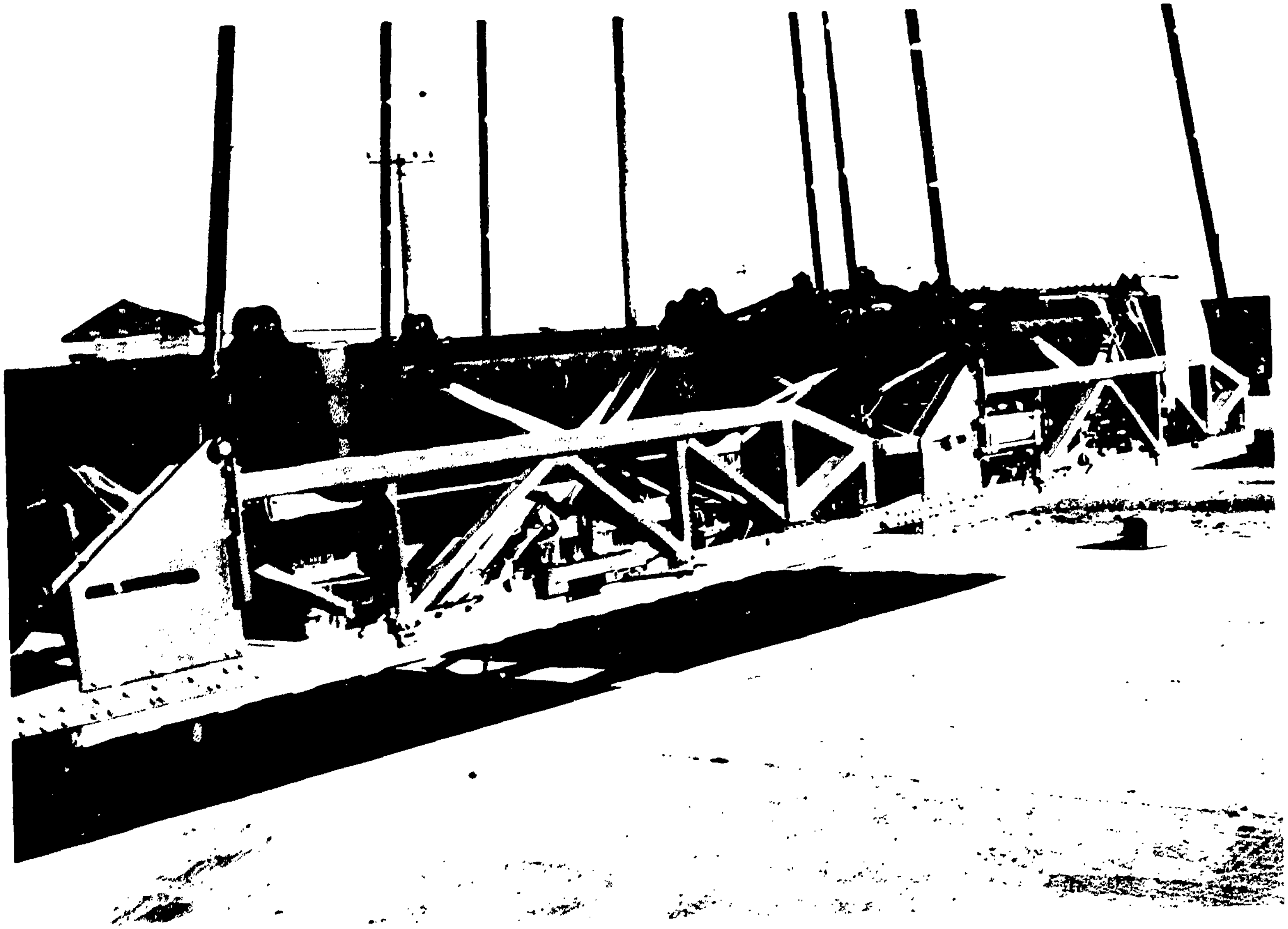


Figure 8. Rigging Provisions

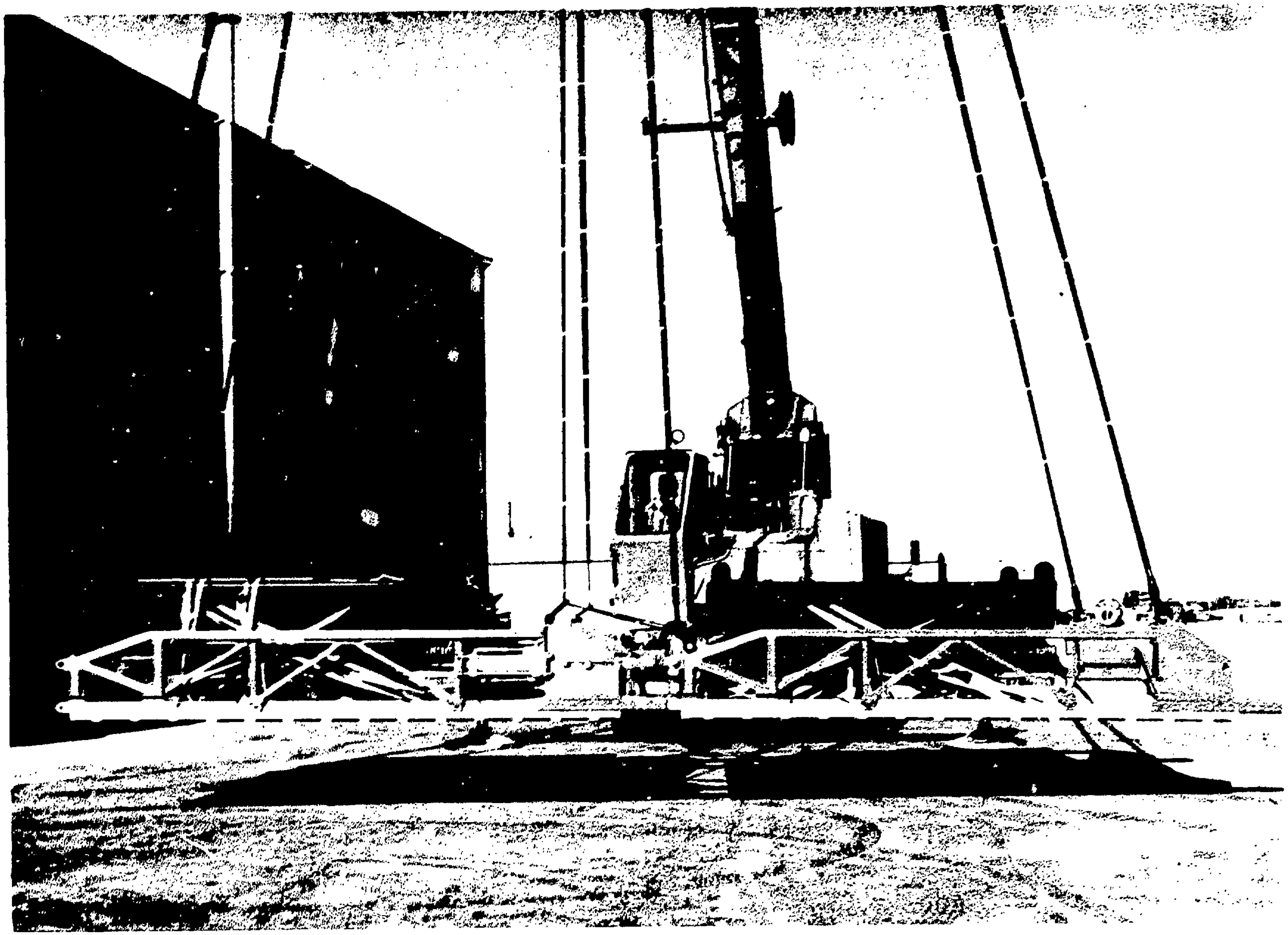


Figure 9. Two-Platform ACES Airdrop Assembly

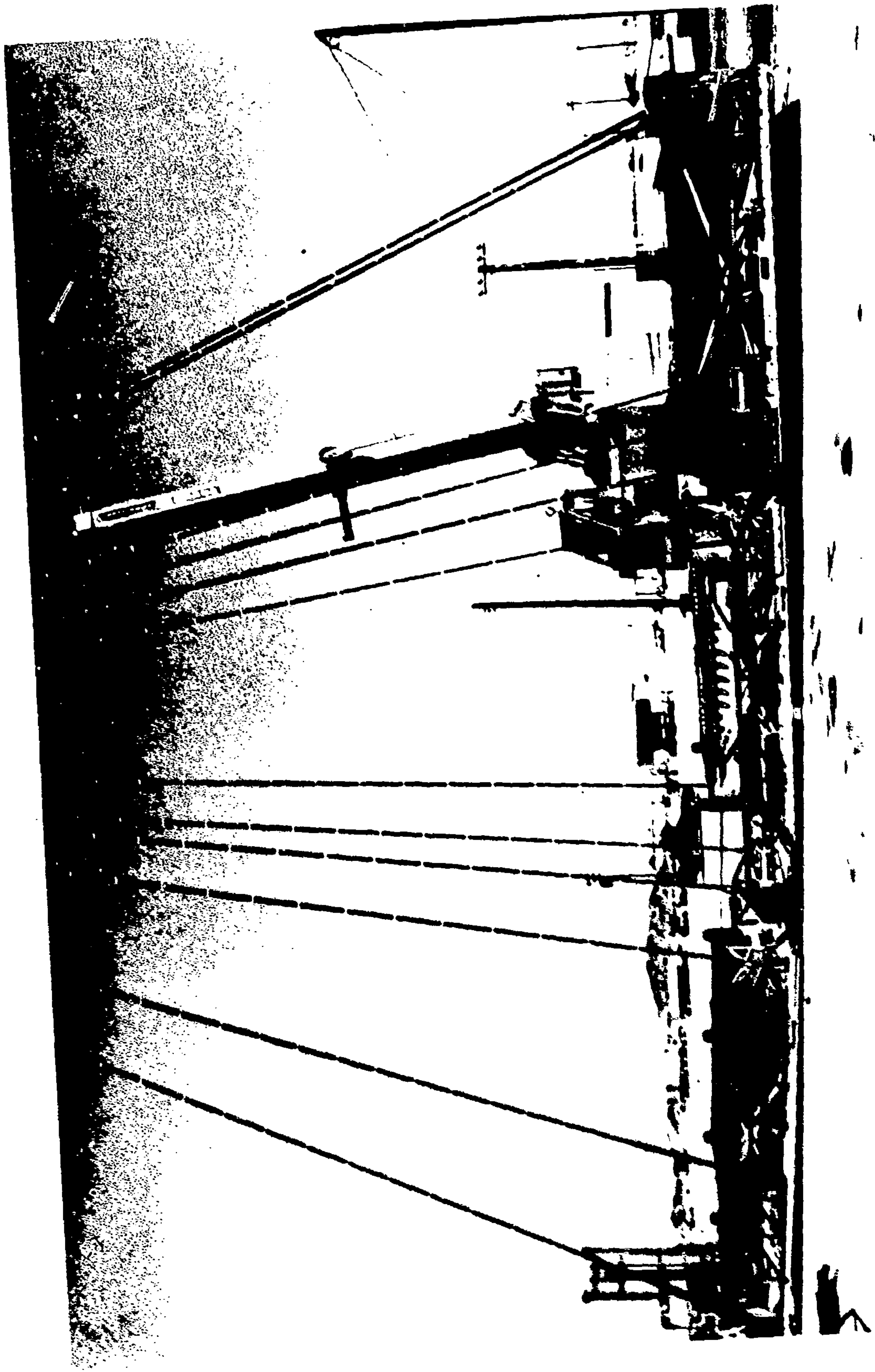


Figure 10. Three-Platform ACES Airdrop Assembly

At the confluence point the suspension lines are attached to the M-2 parachute release mechanism through a set of four, 8-spool connectors. Care must be exercised when installing the M-2 release mechanism to orient the flat or broad side of the mechanism perpendicular to the long axis of the platform assembly. Suspension line arrangements for the two-platform and three-platform assemblies are illustrated in Figures 11 and 12, respectively.

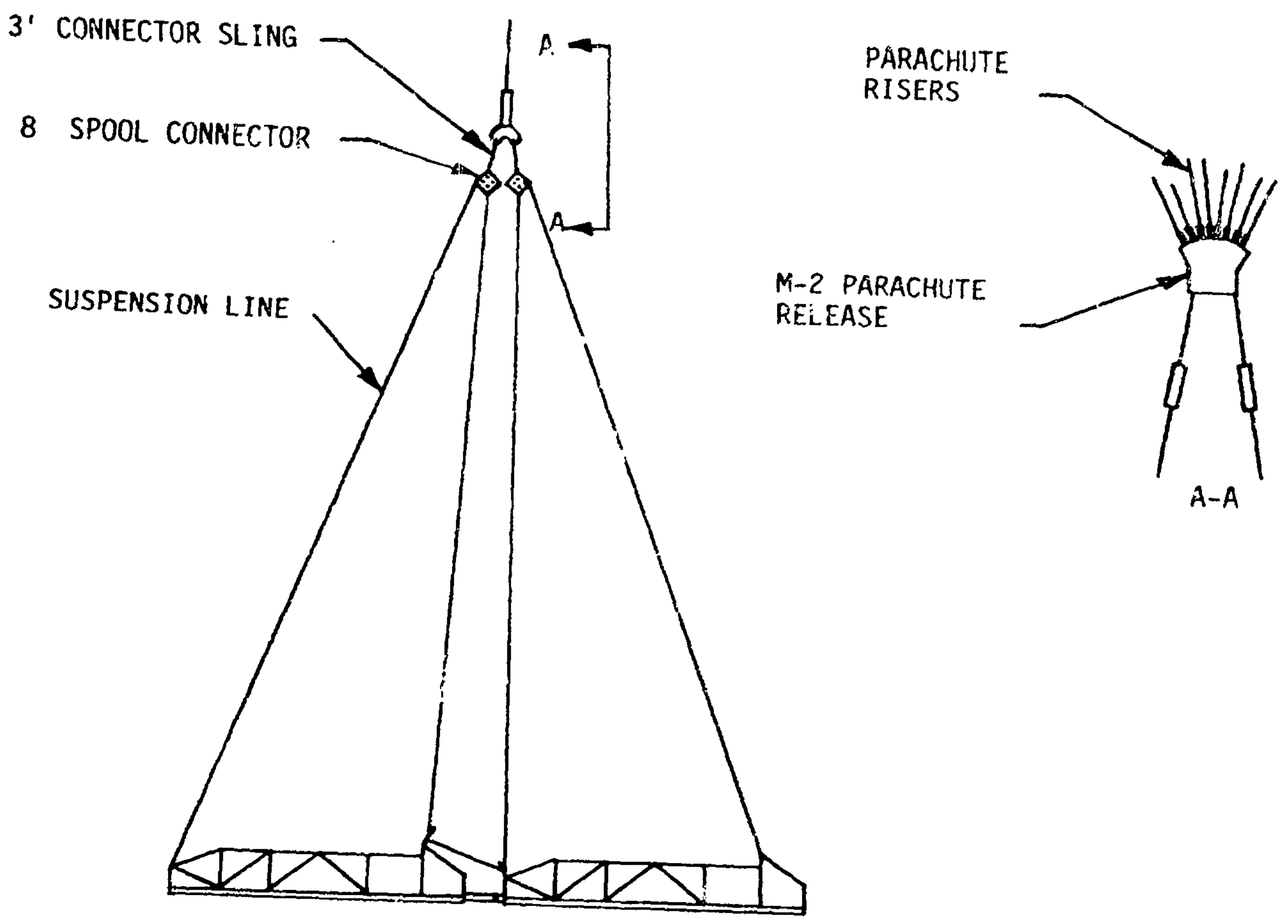


Figure 11. Arrangement of Suspension Lines - Two-Platform Assembly

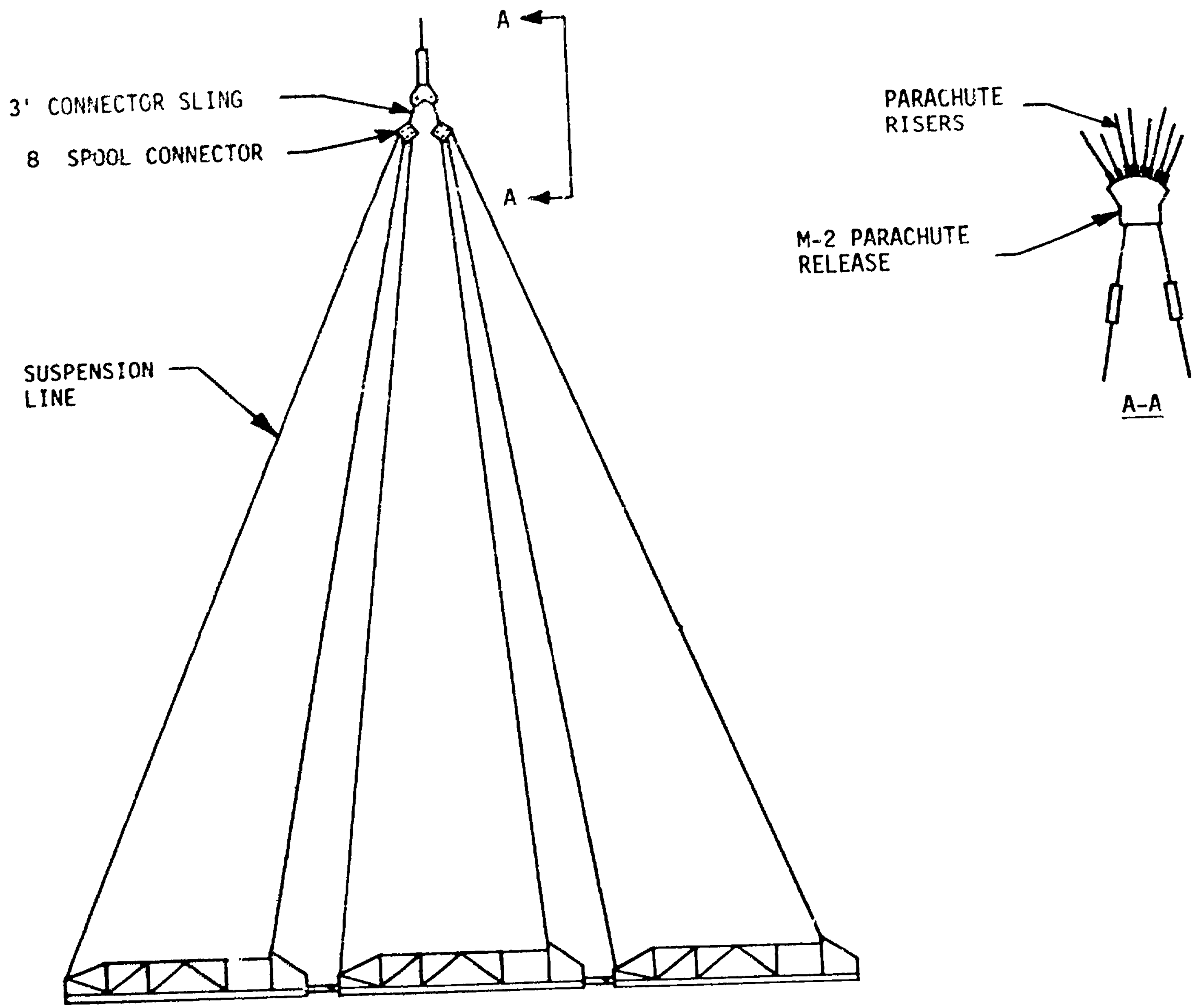


Figure 12. Arrangement of Suspension Lines - 3-Platform Assembly

III. THEORY OF OPERATION

In the ACES mode of operation, the individual platforms are connected so that they are simultaneously extracted from the aircraft in tandem order. The platform rails have been extended and a hinge line incorporated to enable the connections between the platforms. As each platform clears the ramp, it is allowed to rotate in a normal "tip-off" mode. This produces an angular misalignment between the platforms that is arbitrarily defined as a negative displacement angle. Any tendency to reduce this misalignment or rotate in the positive direction is resisted by a hydraulic control device that permits regulated rotation in this direction. The purpose of this constraint is to delay large angular positive displacements long enough for the main recovery parachutes to deploy and gain control of the assembly. Early experiments indicated that these positive rotations would otherwise be large and rapid and sufficient to destroy the equipment loaded on the platforms. This geometry is illustrated in Figure 13.

The moments that are generated at the hinge lines due to the positive rotation constraints are of such magnitude that the rails are incapable of carrying them. Truss style reinforcement structures have been added to the rails of standard metric type platforms to react these moments. The hydraulic components that provide rotational constraint in the positive direction have been incorporated in these reinforcing structures.

Operational characteristics of the ACES system are illustrated in the sequence of illustrations shown in Figures 14 through 18. Figure 14 is a conceptual drawing showing the sequence of events in an ACES airdrop operation. Details of the equipment are illustrated in Figure 15 and Figures 16, 17 and 18 are photographs of a three-platform ACES assembly at various stages in an airdrop test.

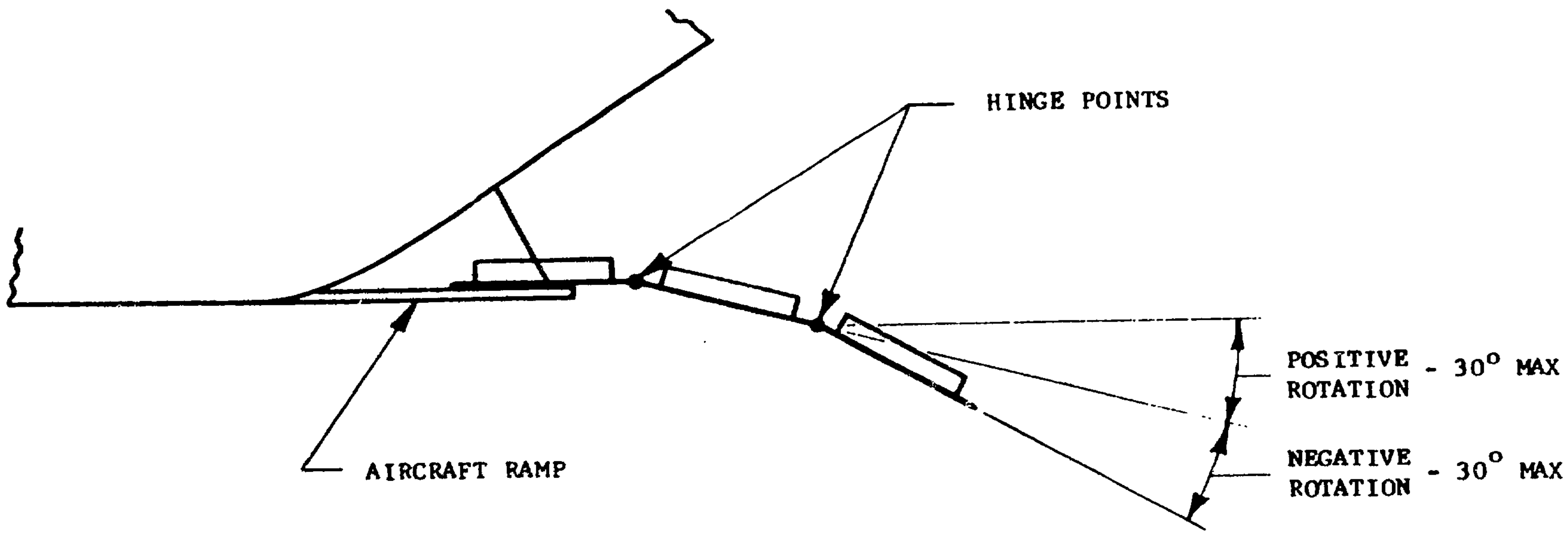


Figure 13. Definitions - Rotation Geometry in ACES System

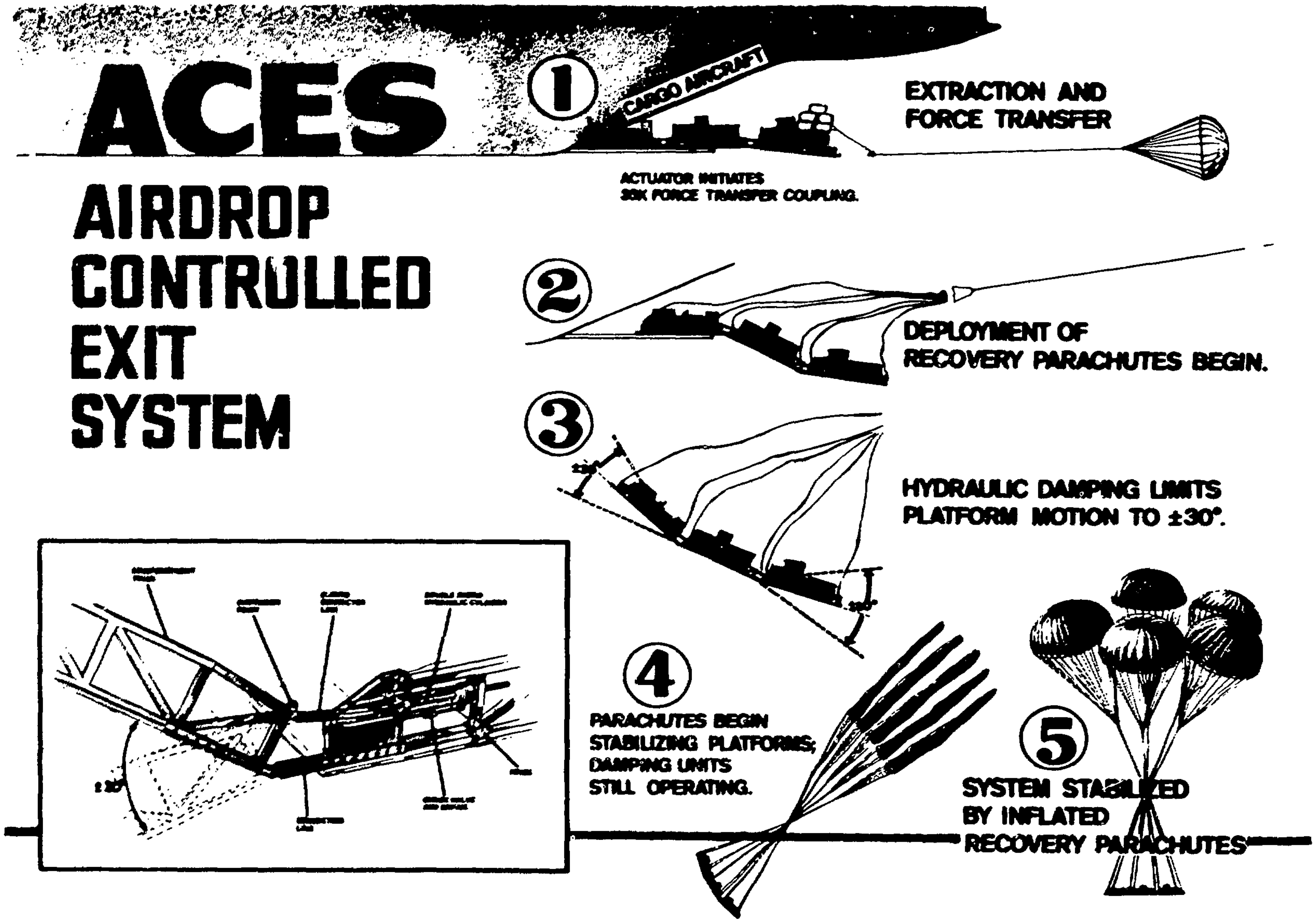


Figure 14. Sequence of Events in an ACES Airdrop

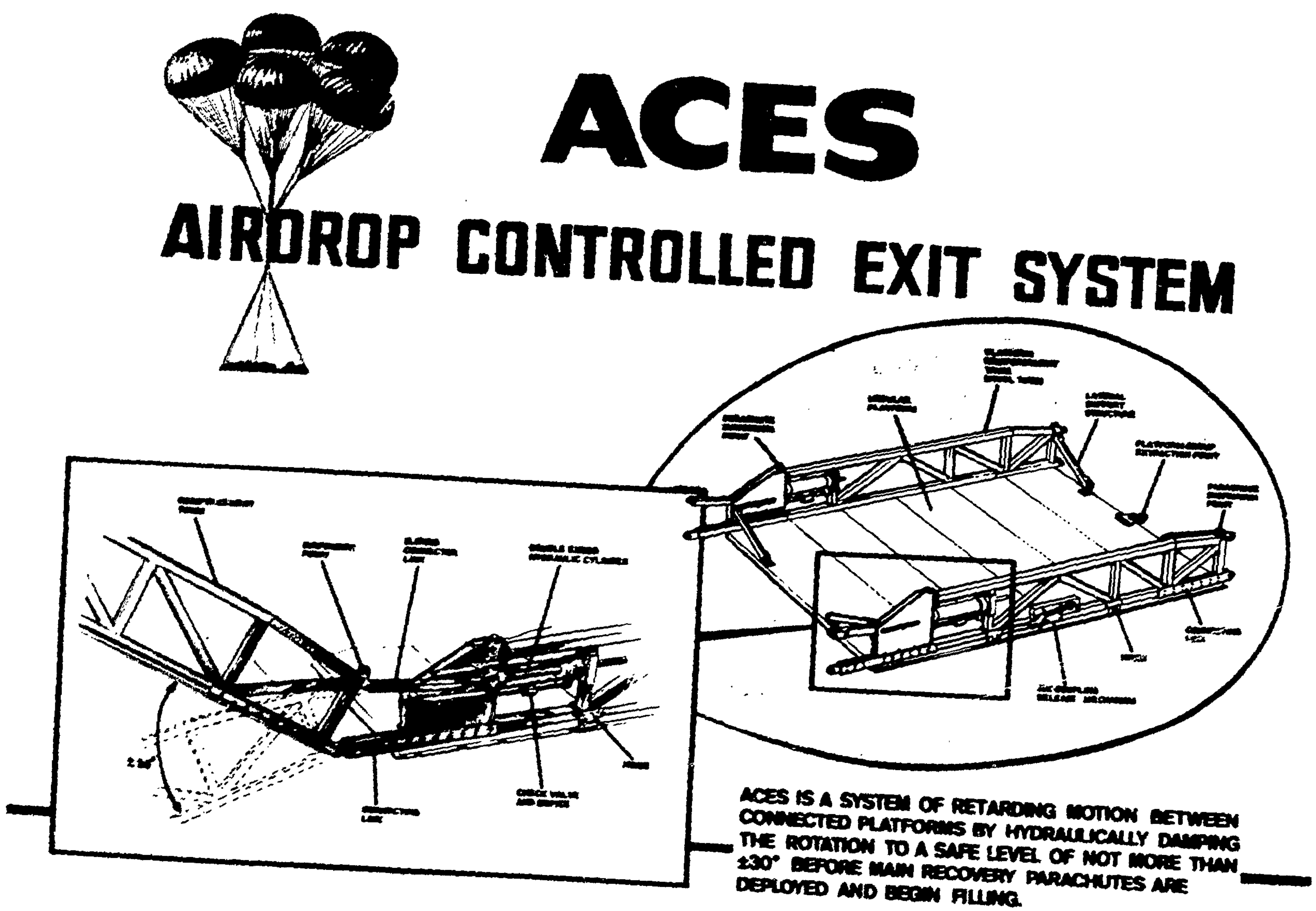


Figure 15. Details of ACES Equipment

Figure 16. Three-Platform ACES Assembly at Extraction

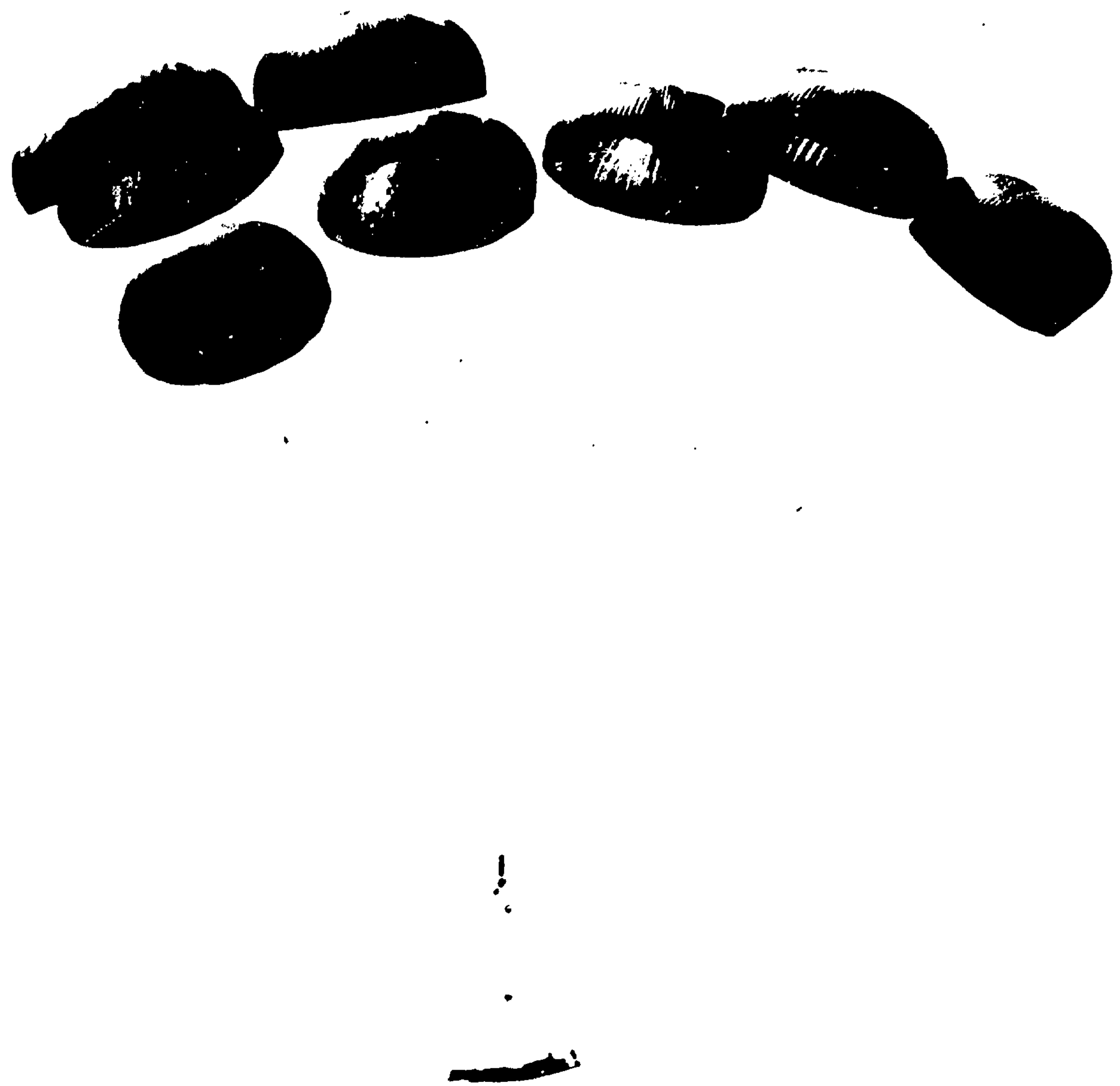


Figure 17. Three-Platform ACES Assembly - Recovery Parachutes Deployed

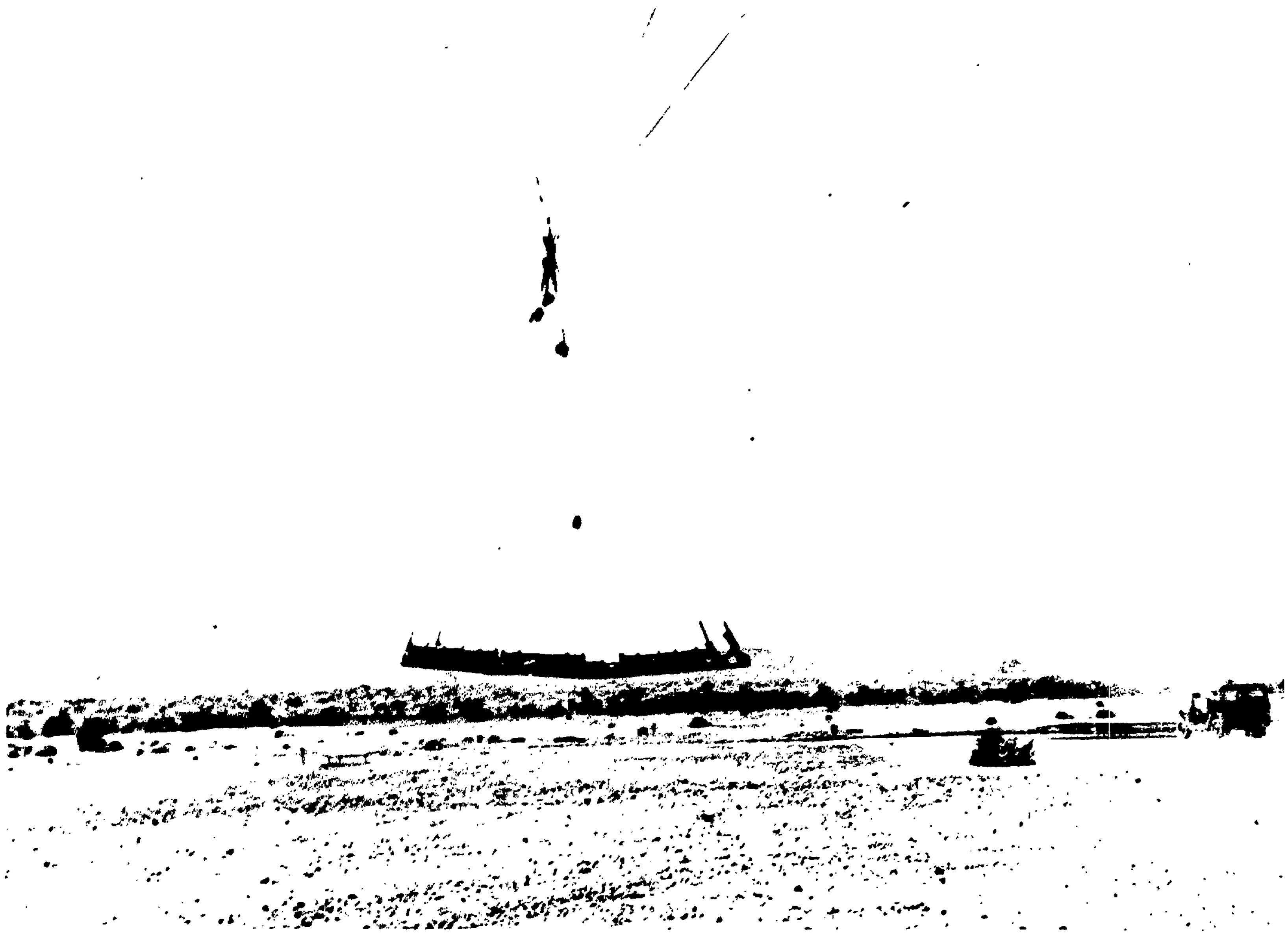


Figure 18. Three-Platform ACES Assembly at Touchdown

IV. SCOPE OF TEST PROGRAM

Original planning provided for thirty drop tests based upon sixteen test drops from the C-130 aircraft, ten from the C-141 aircraft, and four contingency tests which were reserved to investigate special conditions that might arise as a result of the test experience. The test schedule included combinations of two and three platform assemblies made up from platforms 12 feet, 16 feet and 20 feet in length, carrying load weights of minimum, intermediate, and/or maximum capacities. The hardware available to conduct this test program was three 12-foot platforms, one 16-foot platform, and one 20-foot platform.

An accident during the ninth test resulted in the loss of the three 12-foot platform assemblies. One of these units was repaired and combined with the undamaged 16-foot and 20-foot platforms to provide a set of three platforms to continue the test program. The scope of the program was revised to provide twenty test drops.

During the fourteenth drop, an accident caused the loss of the three remaining platform assemblies and the program was terminated. Table 1 provides a listing of the twenty test drop schedule and includes data on the arrangement of the platforms in the airdrop assembly and the platform loadings.

Table 1 - Planning Schedule for Airdrop Tests

Test No.	Platform 1		Platform 2		Platform 3		Total Weight	Aircraft
	Length	Weight	Length	Weight	Length	Weight		
1	12	5,200	12	5,550			10,750	C-130
2	12	8,770	12	5,200			13,970	
3	12	18,000	12	5,200			23,200	
4	12	5,200	12	12,000			17,200	
5	16	6,500	12	5,575			12,075	
6	20	7,500	12	5,575			13,075	
7	20	7,500	16	5,600			13,100	
8	12	4,800	12	5,600	12	5,400	15,800	
9	12	11,870	12	5,600	12	5,400	22,870	C-130
10	20	7,600	16	6,900	12	6,429	20,929	C-141
11	20	17,600	16	7,670	12	6,469	31,739	
12	20	7,600	16	18,100	12	6,750	32,450	
13	16	6,900	20	18,700	12	6,550	32,150	
14	16	17,350	20	8,091	12	6,500	31,991	C-141
15	12	18,000	20	min.	16	min.	30,000	C-141
16	16	24,000	12	min.			29,000	C-130
17	20	max.	12	min.			35,000	
18	20	max.	16	min.			35,000	
19	12	min.	16	max.			35,000	
20	12	min.	20	max.			35,000	C-130

NOTE: NO. 1 Platform was forward in the aircraft.

V. TEST OBJECTIVES

The objectives of this Engineering Development Test program were as follows:

1. Collect data for evaluation of the ACES concept on the behavior and performance of interconnected platforms during parachute extraction, load transfer, snatch, and deployment and opening of the recovery parachutes with various weight loads on various length platforms.
2. Determine and define problems which may result from this type of airdrop, particularly those associated with stability of the platforms immediately following extraction of the loads from the aircraft.
3. Collect data for determining the stresses developed in the platforms and platform reinforcement trusses, relative torque, and amount of rotation between adjacent platforms.
4. Evaluate the rigging and de-rigging procedures used with ACES reinforcement structure.
5. Develop aircrew procedures for accomplishment of an airdrop using ACES equipment.
6. Determine the compatibility of the ACES system with the aircraft.
7. Acquire parachute ballistic data for the ACES system.

VI. TEST PROCEDURES

A. Data Requirements and Instrumentation

Data was collected by photographic coverage and instrumentation. The instrumented data was transmitted to a ground installation by telemetry. The following is a listing of the data that was acquired during the tests:

1. Event Times
    a. First motion
    b. Load transfer release
    c. Recovery parachute bag movement
    d. Time at tip-off
    e. Suspension line snatch times
    f. Full inflation
    g. Impact
2. Cinetheodolite Data
    a. Three coordinate position data versus time
    b. Three coordinate velocities and total velocity versus time
3. Meteorological Data
    a. Launch altitude
    b. Wind velocity and direction
    c. Pressure
    d. Temperature
4. Photographic
    a. GROUND-TO-AIR color motion picture at 200 frames per second with time correlation. Coverage through full inflation of the recovery parachutes plus 15 seconds- two or more camera coverage
    b. GROUND-TO-AIR motion picture at real time covering the entire drop
    c. AIR-TO-AIR color motion picture at 200 frames per second to cover the entire drop.
    d. On-board aircraft coverage of load extraction.

e. Selected documentary motion picture coverage of rigging the load, loading, and actual airdrop

f. Documentary still photographs covering all aspects of airdrop procedures.

5. Video Tape

a. Video tape of each test for immediate evaluation of system performance

6. Telemetered Data

Table 2 provides a list of data that was telemetered and recorded. The location of the instrumentation on the two- and three-platform assemblies is shown in Figures 19 and 20, respectively. The amount of instrumentation varied from test to test and some of the instrumentation failed to produce usable data. Table 3 provides a key to show where instrumentation was installed and which instruments produced usable data.

Table 2. List of Instrumentation

Locator No.	Description
1	Green Light
2	First Motion
3	Angular Rotation, Hinge Line
4	Angular Rotation, Aft Hinge Line
5	Angular Rotation, Forward Hinge Line
6	Compression Link, Hinge Line, Right and Left Side
7	Compression Link, Aft Hinge Line, Right and Left Sides
8	Compression Link, Forward Hinge Line, Right and Left Sides
9	Truss, Aft Platform, Forward End, Right and Left Sides
10	Rail, Aft Platform, Forward End, Right and Left Sides
11	Truss, Center Platform, Aft End, Right and Left Sides
12	Rail, Center Platform, Aft End, Right and Left Sides
13	Truss, Center Platform, Forward End, Right and Left Sides
14	Rail, Center Platform, Forward End, Right and Left Sides
15	Truss, Forward Platform, Aft End, Right and Left Sides
16	Rail, Forward Platform, Aft End, Right and Left Sides
17	Sling, Aft Platform, Aft End, Right and Left Sides
18	Sling, Center Platform, Aft End, Right and Left Sides
19	Sling, Forward Platform, Aft End, Right and Left Sides
20	Sling, Forward Platform, Forward End, Right and Left Sides

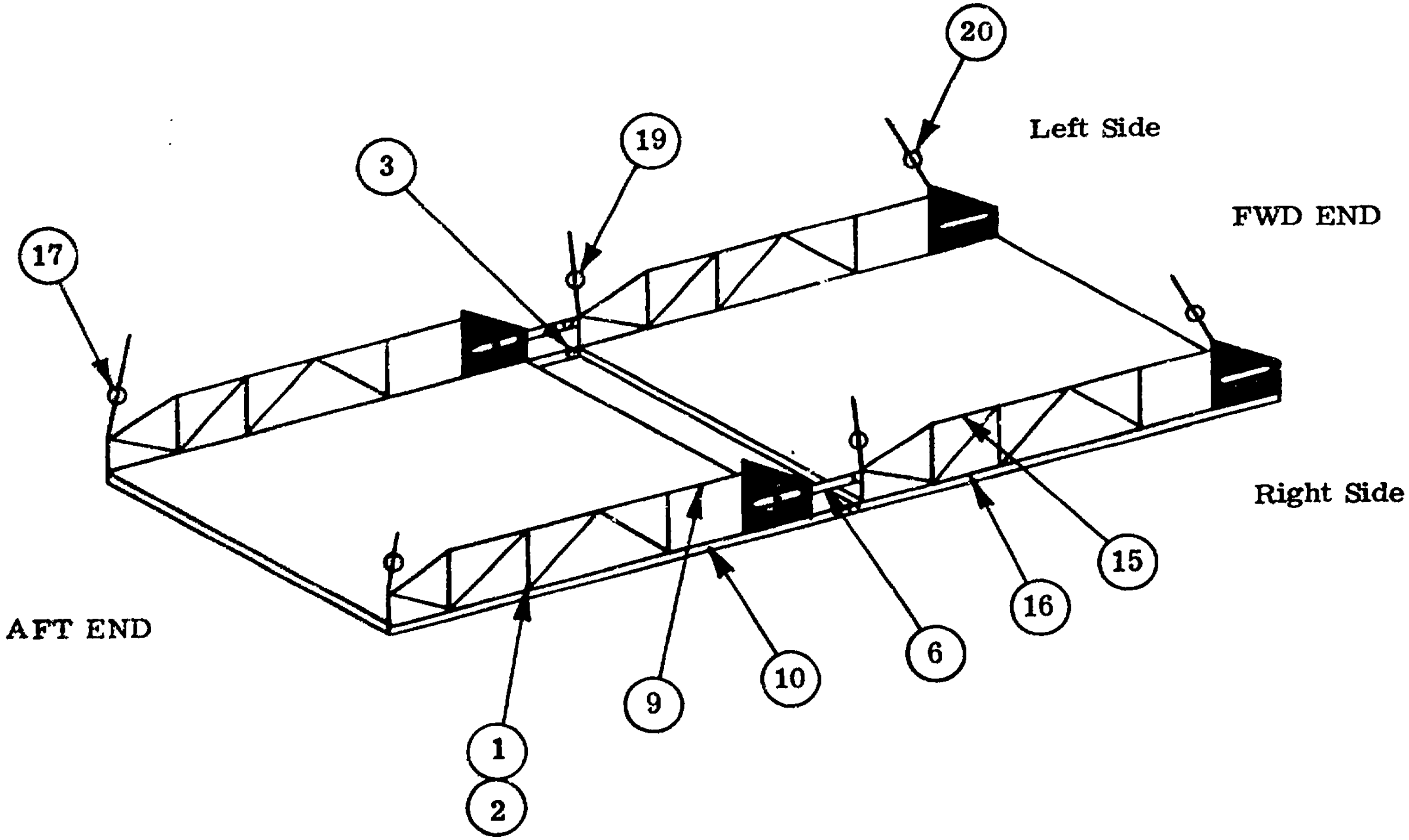


Figure 19. Location of Instrumentation - Two-Platform Assembly

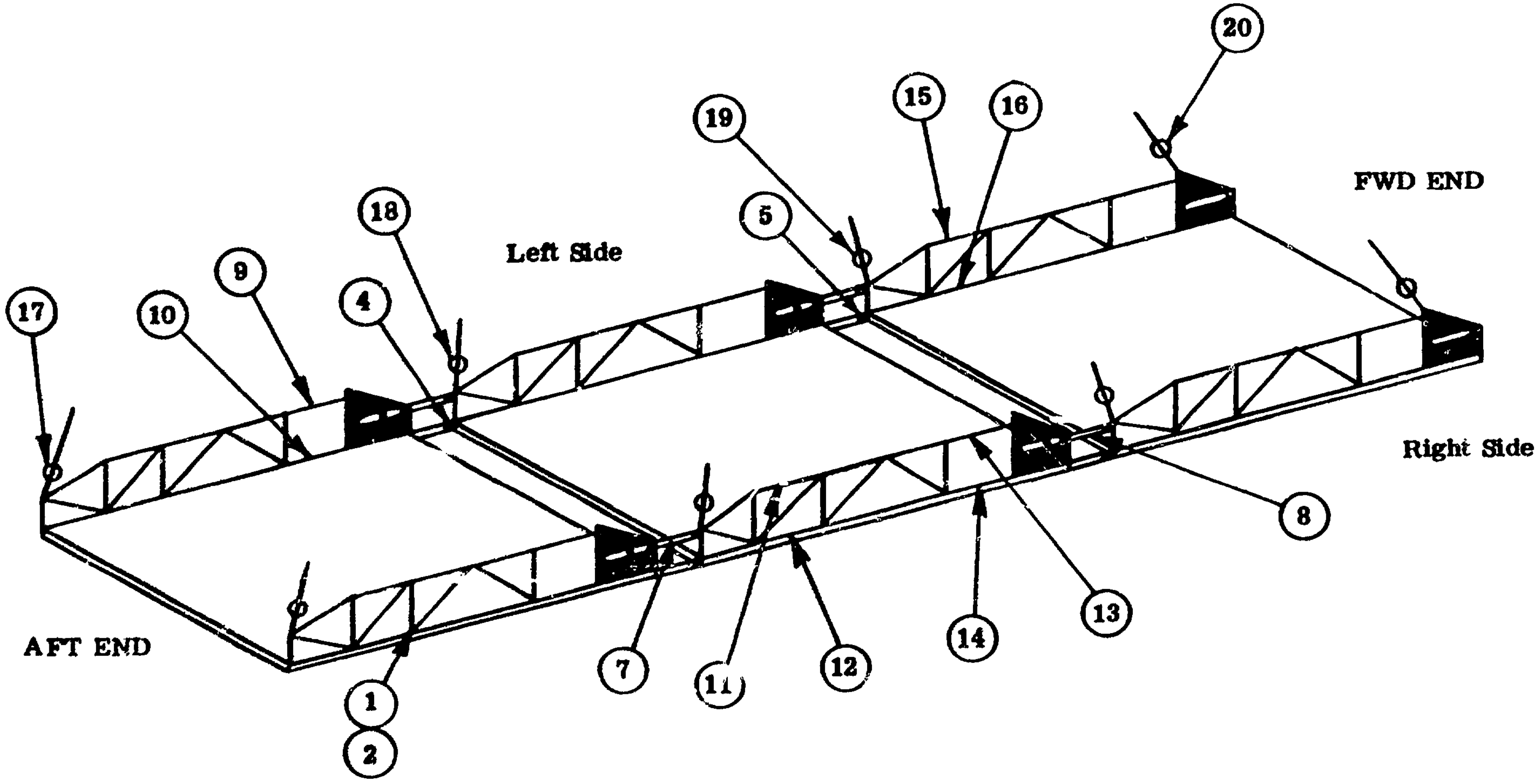


Figure 20. Location of Instrumentation - Three-Platform Assembly

Table 3. Summary of Instrumented Data Channels

		ACES DROP NO.													
LOC. NO.		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1		●	▲	●	●	●	●	●	●	●	●	●	▲	●	●
2		●	▲	●	●	●	●	●	●	●	●	●	▲	●	●
3		▲	▲	●	●	●	●	●							
4									●	●	●	●	▲	●	●
5									●	●	●	●	▲	●	●
6	R	▲	▲	▲	▲	●	●	●							
	L	▲	▲	▲	▲	●	●	●							
7	R								●	●	▲	●	▲	●	●
	L								●	●	●	●	▲	●	●
8	R								●	●	▲	●	▲	●	●
	L								●	●	●	●	▲	●	●
9	R			▲	●	●	●	●	●	●					
	L			▲	●	▲	▲	●	▲	●					
10	R			▲	▲	●	●	●	●	●					
	L			▲	●	●	●	●	▲	●					
11	R								●	●	●	●	▲	▲	●
	L								●	●	●	●	▲	●	●
12	R								●	▲	●	●	▲	●	●
	L								▲	●	●	●	▲	▲	●
13	R								●	●	●	●	▲	●	●
	L								●	●	●	●	▲	●	●
14	R								●	●	●	●	▲	▲	●
	L								●	●	●	●	▲	●	●
15	R			▲	●	●	●	●	▲	●					
	L			▲	●	●	●	●	●	●					
16	R			▲	▲	●	▲	●	●	●					
	L			▲	●	▲	●	●	●	●					
17	R	●	▲	●	▲	●	●	●	●	●	●	●	▲	●	●
	L	●	▲	●	▲	▲	●	●	●	●	▲	●	▲	▲	●
18	R								●	●	▲	●	▲	●	●
	L								●	●					
19	R	▲	▲	▲	▲	▲	●	●	●	●	▲	▲	▲	●	●
	L	●	▲	▲	▲	●	●	●	●	●					
20	R	▲	▲	●	▲	●	●	●	●	●	●	●	▲	●	●
	L	▲	▲	▲	▲	●	●	●	●	●	●	●	▲	●	●

● - Instrumented Data Obtained

▲ - Instrumented Data Lost

R - Right Side of Platform

L - Left Side of Platform

B. Test Responsibilities and Methods

The testing was conducted by the US Army Test and Evaluation Command at their Yuma Proving Ground facilities in accordance with directives issued by the US Army Natick Research and Development Laboratories. Yuma Proving Ground provided the facilities, arranged for the aircraft, and provided the services to rig and instrument the loads, conduct the tests and acquire and process the data. The US Air Force Aeronautical Systems Division (ASD), WPAFB and the US Air Force Military Airlift Command (MAC) developed aircrew procedures, provided technical advice, and monitored aircraft safety provisions. Technical services were furnished by the AAI Corporation to assist in planning and conduct of the tests and maintenance of the equipment. Analysis of the data and preparation of the test report was also an AAI responsibility.

The ACES system was conceived to function in a manner identical to current heavy load platform airdrop; therefore, no procedural innovations were required in accomplishing the actual airdrop. The drop altitude was a nominal 1500 feet and the aircraft speed was 130 knots from the C-130 aircraft and 150 knots from the C-141 aircraft. The aircrew aligned the aircraft over the drop zone and performed the airdrop in accordance with standard airdrop operating procedures.

VII. DATA PROCESSING AND ANALYSIS

A. Definitions

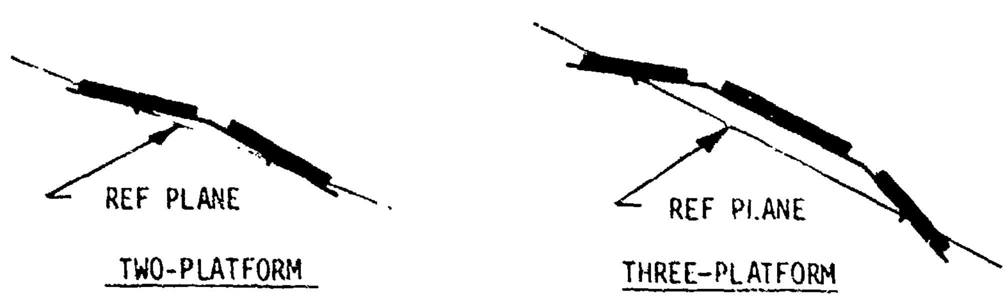
The following definitions are provided of terms used in the test program to designate events in an airdrop test.

1. GREEN LIGHT - This is a light that comes on in the Cargo Compartment indicating that the navigator has initiated the airdrop. Release of the pendulum that launches the extraction parachute(s) occurs simultaneously with the illumination of this light. This event is telemetered and indicated on all instrumentation records.

2. FIRST MOTION - The first movement of the load by the extraction parachute. This is detected by the break of an electrical circuit. It is telemetered and recorded on all instrumentation records.

3. TIP-OFF - The rotation of the platforms induced by gravity as the platforms pass over the end of the ramp. Tip-off is considered to be complete when the forward platform clears the ramp. The timing of this event is obtained from the film records. Rotation of the load in the tip-off direction or clockwise as viewed from the left side of the aircraft, is defined as negative rotation. Rotation in the opposite direction is positive rotation.

4. REFERENCE PLANE - For a two-platform assembly this is the hypothetical plane that intersects the two platforms in lines at their mid-points. In a three-platform assembly this hypothetical plane intersects the two end platforms in lines at their mid points. This is illustrated in the following sketch.

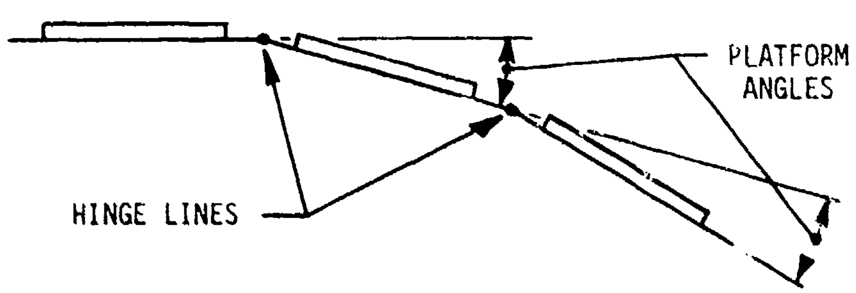


This hypothetical plane can be located readily on the film records and is used to define the attitude and rotational motion of the platform assemblies. The convention used to define negative and positive rotation at tip-off is also used here to describe the motion of the assembly during the period following tip-off until the recovery parachutes have the assembly under control.

5. EXTRACTION RELEASE - The point in the extraction process where the pull of the extraction parachute(s) is transferred to the deployment bags of the recovery parachutes. This event occurs as the release mechanism clears the end of the ramp of the aircraft.

6. EXTRACTION VELOCITY - The maximum velocity imparted to the assembly by the extraction parachute(s) during the extraction process.

7. ANGLE BETWEEN PLATFORMS - The angle measured at the hinge line(s) between the platform planes. These angles are illustrated in the following sketch.



B. Test Data

The data obtained during each of the fourteen drop tests is provided in the following presentations. The behavior of the platform assemblies and the time of occurrence of several of the events were obtained from the film records using a film analyzer. Loads in various elements of the system and angles between the platforms were obtained from the telemetered instrument data. Copies of these records are included in the appendix. Trajectory data was also obtained, but this data was of prime interest to the US Air Force Aeronautical Systems Division for use in evaluating parachute performance in the ACES system, therefore, this information was furnished to ASD and is not included in this report.

DROP #1

This was a two-platform drop configuration utilizing two 12-foot platforms. The respective platform loads were 5,200 lb on the forward and 5,550 lb on the aft platform. The orifices in the hydraulic lines were set at 0.070-in. diameter which was selected following static tests at AAI Corporation. The center of gravity was aft of center at 54 percent of the assembled length. The load-transfer actuator was installed on the forward platform. This location was selected to assure complete exit of the assembly from the aircraft before deployment of the recovery parachutes. Extraction and exit from the aircraft was good. The attitude of the assembly at the completion of tip-off was -7^{o}, but the assembly continued rotation and reached -210^{o} before it stopped and reversed direction. Because of this large amount of rotation, one of the suspension slings became entangled on the rail extension of the forward platform. As the load was descending, the platform assembly had a roll angle of approximately 30^{o}, but just prior to impact this angle decreased to approximately 10^{o}. The assembly skidded along the ground about 20 feet after touchdown. This rough action sheared some bolts that attach the reinforcement truss to the rail. This damage was easily repaired. The hydraulic controls operated properly and were in good condition. Instrumentation of the platform rails and trusses was not completed in time for this test. The compression links were instrumented but did not function well enough to give usable data. The suspension slings were instrumented with strain links placed at the apex of the suspension slings and the wiring ran down the slings to the platform. Out of the six slings that were instrumented, only three provided usable data. The other three suffered broken wires.

DROP DATA TEST NO. 1

DATE	10/26/79
TIME	3:00 PM
WIND VELOCITY	8 to 10 MPH
WIND DIRECTION	270°
AIRCRAFT	C-130
A/C VELOCITY	130 KTS
A/C HEADING	206°
A/C ALTITUDE	2500 FT AGL

PLATFORM CONFIGURATION

NO. OF PLATFORMS 2

ARRANGEMENT:	FWD	AFT
LENGTH:	12 FT	12 FT
WEIGHT:	5,200 LB	5,550 LB

LENGTH OF PLATFORM ASSY.	25.33 FT
C.G. LOCATION FROM FWD END	13.74 FT
PERCENTAGE FROM FWD END	54%
EXTRACTED WEIGHT	11,500 LB
HYDRAULIC CYLINDER ORIFICE DIAMETER	0.070 IN.

RIGGING DATA

PARACHUTES:

EXTRACTION	22' RS
NO. OF CHUTES	1

RECOVERY G-11A

NO. OF CHUTES 3

EXTRACTION LINE LENGTH . . . . 60 FT

EXTRACTION RELEASE

TYPE 35K

LOCATION FROM FWD EDGE OF PLATFORM ASSY . . . . 5.66 FT

PARACHUTE RELEASE M-2

SUSPENSION SLINGS

LOCATION:	FWD	CENTER	AFT
LENGTH:	30.5 FT	60 FT	31 FT

PERFORMANCE DATA

TIME:

GREEN LIGHT TO FIRST MOTION . . . . 3.28 SEC

FIRST MOTION TO EXTRACTION RELEASE . . . . 1.49 SEC

FIRST MOTION TO TIP OFF OF FWD PLATFORM . . . . 1.59 SEC

GREEN LIGHT TO IMPACT . . . . -

EXTRACTION VELOCITY . . . . 38.7 FPS

ROTATION:

ANGLE AT TIP OFF:

PLATFORM REF PLANE . . . . -6.8^{o}

FWD PLATFORM . . . . -6.4^{o}

ANGLE BETWEEN PLATFORMS:

MAX. POS ANGLE . . . . -

MAX. NEG ANGLE . . . . -

PLATFORM REF PLANE MAX. ANGLE . . . . -210.7^{o}

DESCENT:

TIME FROM TIPOFF TO FULL CANOPY	14.2 SEC
TIME FROM TIPOFF TO ZERO FORWARD VELOCITY.	7.5 SEC
TIME FROM TIPOFF TO STABLE RATE OF DESCENT	14.8 SEC
ALTITUDE LOSS TO REACH VERT. VELOCITY OF 28.5 FPS .	.
VERTICAL VELOCITY AT IMPACT.	28 FPS
HORIZONTAL VELOCITY AT IMPACT	-
AVERAGE DESCENT RATE	25 FPS

INSTRUMENTED DATA

COMPRESSION LINK LOADS:

	PEAK	STEADY STATE
RIGHT SIDE:	-	-
LEFT SIDE:	-	-

TRUSS LOADS, PEAK

LOCATION:	FWD	AFT
RIGHT SIDE:	-	-
LEFT SIDE:	-	-

RAIL LOADS, PEAK

LOCATION:	FWD	AFT
RIGHT SIDE:	-	-
LEFT SIDE:	-	-

SLING LOADS, PEAK

LOCATION:	FWD	CENTER	AFT
RIGHT SIDE:	-	-	8,375 LB
LEFT SIDE:	-	4,225 LB	9,446 LB

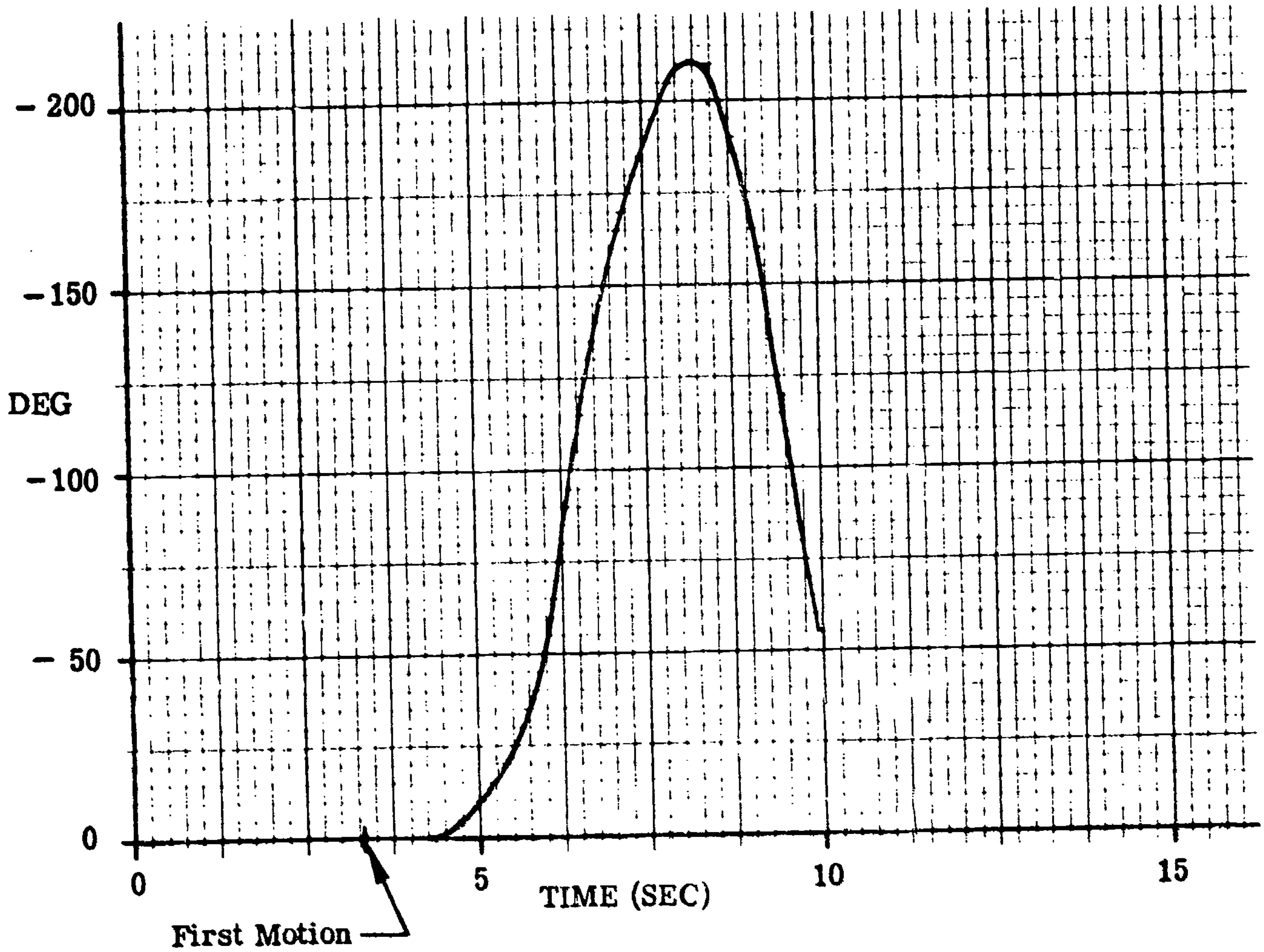


Figure 21. Platform Ref. Plane Angle vs. Time, ACES Drop #1

DROP #2

This was a two-platform drop configuration utilizing two 12-foot platforms. The respective platforms' loads were 8,770 lb on the forward and 5,200 lb on the aft platform. The orifices in the hydraulic lines were left at the 0.070-in. diameter setting as this setting appeared to function quite well. The center of gravity was forward of center at 47 percent of the assembled length. The load-transfer actuator was installed on the aft platform. This was done in an attempt to reduce the amount of platform assembly rotation by deploying the recovery parachutes earlier. It was reasoned that the recovery parachutes, if deployed earlier, would gain control of the assembly before rotation reached a large angle. After reviewing films of the previous drop it was concluded that early extraction release would pose no danger to the aircraft. In an attempt to eliminate the sling entanglement problems of the previous drop, the rail extension on the forward platform was removed and a "dead man" was tied to the suspension slings. The "dead man" is a line tied from sling to sling, parallel to the platform, about 7 feet above the platform. Its purpose is to keep the slings from getting underneath the platforms.

Extraction and exit from the aircraft was good. Rotation between platforms was controlled satisfactorily by the hydraulic cylinders. The platform assembly rotated through -88^0 before the aft sling became taut at 2.22 seconds after tip-off and rotation was reversed. There were no sling entanglements and the load became stable very quickly. The platforms landed on a 15^0 to 20^0 slope so that first contact with the ground was concentrated along one side of the platform. As a result, several bolts were sheared off or bent and had to be replaced. The platform rail was bowed up about 1 inch, 4 feet back from the hinge point end of the platform. The hydraulic cylinders were undamaged. Instrumentation of the platform rails and trusses was incomplete for this test. The compression links were instrumented but failed to provide usable data. Strain links were placed at the apex of the suspension slings and the wires ran down the slings to the platform. No sling data were obtained because of broken wires.

DROP DATA TEST NO. 2

DATE	10/31/79
TIME	2:30 PM
WIND VELOCITY	3 TO 5 MPH
WIND DIRECTION	180^{o}
AIRCRAFT	C-130
A/C VELOCITY	130 KTS
A/C HEADING	206^{o}
A/C ALTITUDE	2460 FT AGL

PLATFORM CONFIGURATION

NO. OF PLATFORMS 2

ARRANGEMENT:	FWD	AFT
LENGTH:	12 FT	12 FT
WEIGHT:	8,770 LB	5,200 LB

LENGTH OF PLATFORM ASSY.	25.33 FT
C.G. LOCATION FROM FWD END	11.82 FT
PERCENTAGE FROM FWD END	47%
EXTRACTED WEIGHT	14,970 LB
HYDRAULIC CYLINDER ORIFICE DIAMETER	0.070 IN.

RIGGING DATA

PARACHUTES:

EXTRACTION	28' RS
NO. OF CHUTES	1

RECOVERY G11-A

NO. OF CHUTES 4

EXTRACTION LINE LENGTH . . . . 60 FT

EXTRACTION RELEASE

TYPE . . . . 35 K

LOCATION FROM FWD EDGE OF PLATFORM ASSY . . . . 18.75 FT

PARACHUTE RELEASE M-2

SUSPENSION SLINGS

LOCATION:	FWD	CENTER	AFT
LENGTH:	60 FT	120 FT	60 FT

PERFORMANCE DATA

TIME:

GREEN LIGHT TO FIRST MOTION . . . . 3.46 SEC

FIRST MOTION TO EXTRACTION RELEASE . . . . .98 SEC

FIRST MOTION TO TIP OFF OF FWD PLATFORM . . . . 1.44 SEC

GREEN LIGHT TO IMPACT . . . . -

EXTRACTION VELOCITY . . . . 40 FPS

ROTATION:

ANGLE AT TIP OFF:

PLATFORM REF PLANE . . . . -5.4^{0}

FWD PLATFORM . . . . -1.4^{0}

ANGLE BETWEEN PLATFORMS:

MAX. POS ANGLE . . . . -

MAX. NEG ANGLE . . . . -

PLATFORM REF PLANE MAX. ANGLE . . . . -88^{0}

DESCENT:

TIME FROM TIPOFF TO FULL CANOPY . . . . -

TIME FROM TIPOFF TO ZERO FORWARD VELOCITY. . . . . -

TIME FROM TIPOFF TO STABLE RATE OF DESCENT . . . . -

ALTITUDE LOSS TO REACH VERT. VELOCITY OF 28.5 FPS . -

VERTICAL VELOCITY AT IMPACT . . . . -

HORIZONTAL VELOCITY AT IMPACT . . . . -

AVERAGE DESCENT RATE . . . . -

INSTRUMENTED DATA

COMPRESSION LINK LOADS:

	PEAK	STEADY STATE
RIGHT SIDE:	-	-
LEFT SIDE:	-	-

TRUSS LOADS, PEAK

LOCATION:	FWD	AFT
RIGHT SIDE:	-	-
LEFT SIDE:	-	-

RAIL LOADS, PEAK

LOCATION:	FWD	AFT
RIGHT SIDE:	-	-
LEFT SIDE:	-	-

SLING LOADS, PEAK

LOCATION:	FWD	CENTER	AFT
RIGHT SIDE:	-	-	-
LEFT SIDE:	-	-	-

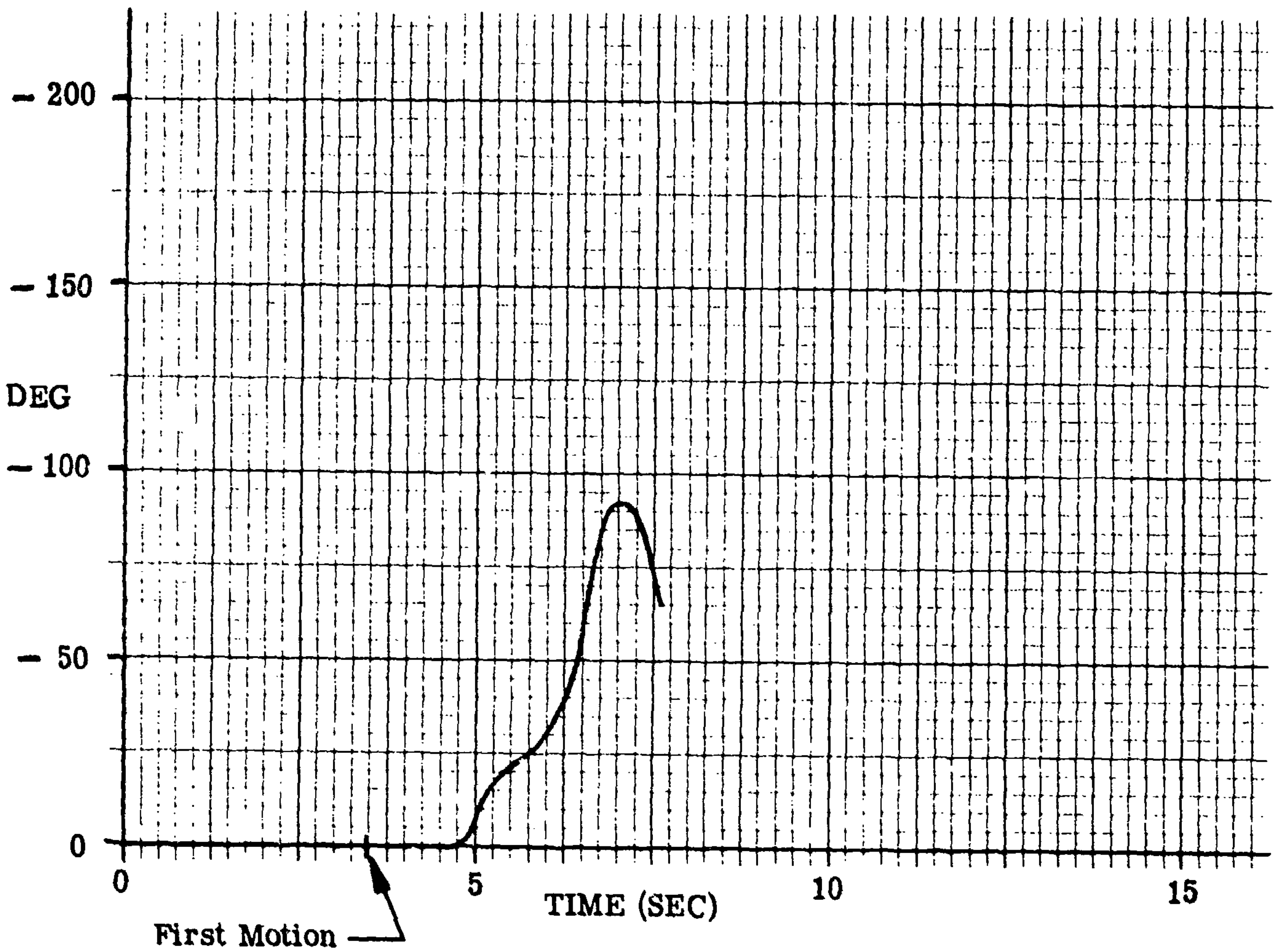


Figure 22. Platform Ref. Plane Angle vs. Time, ACES Drop #2

DROP #3

This was a two-platform drop configuration utilizing two 12-foot platforms. The respective platform loads were 18,000 lb on the forward and 5,200 lb on the aft platform. The orifices in the hydraulic lines were set at 0.070-in. diameter. The center of gravity was forward of center at 36 percent of the assembled length. The load-transfer actuator was installed on the aft platform. Line bags were used to house the forward suspension slings.

Extraction and exit from the aircraft was good. At tip-off the platform reference plane angle was -17.30^{0} and rotating clockwise. Due to the considerable sail area aft of the C.G., the wind forces reversed the direction of tip-off induced rotation about 1.0 seconds after tip-off. At 1.78 seconds after tip-off, the forward suspension slings became taut and rotation was again reversed to the negative direction. Rotation increased to a maximum of -58.5^{0} at 3.0 seconds after tip-off.

Performance of the system was good. At touchdown one end of the assembly dug into the slope of a small hill and caused some structural damage. The end panel was damaged extensively and had to be replaced. Also, several bolts were sheared along one rail and the truss on one side of the platform was bowed slightly. All of this damage was relatively easy to repair.

Instrumentation performance was poor. One antenna was damaged which wiped out quite a lot of the data. The compression link instruments gave poor quality data. Plans were made to change the strain gages to units with greater sensitivity. Also, strain links mounted at the apex of the suspension slings are highly susceptible to broken lead wires. It was planned to locate these strain links at the platform end in the future.

DROP DATA TEST NO. 3

DATE	11/14/79
TIME	2:00 PM
WIND VELOCITY	3 TO 8 MPH
WIND DIRECTION	90°
AIRCRAFT	C-130
A/C VELOCITY	130 KTS
A/C HEADING	206°
A/C ALTITUDE	2000 FT AGL

PLATFORM CONFIGURATION

NO. OF PLATFORMS 2

ARRANGEMENT:	FWD	AFT
LENGTH:	12 FT	12 FT
WEIGHT:	18,000 LB	5,200 LB

LENGTH OF PLATFORM ASSY.	25.33 FT
C.G. LOCATION FROM FWD END	9.16 FT
PERCENTAGE FROM FWD END	36%
EXTRACTED WEIGHT	24,700 LB
HYDRAULIC CYLINDER ORIFICE DIAMETER	0.070 IN.

RIGGING DATA

PARACHUTES:

EXTRACTION	28' RS
NO. OF CHUTES	1

RECOVERY	G-11A
NO. OF CHUTES	6
EXTRACTION LINE LENGTH	60 FT
EXTRACTION RELEASE:	
TYPE	35 K
LOCATION FROM FWD EDGE OF PLATFORM ASSY	18.75 FT
PARACHUTE RELEASE	M-2

SUSPENSION SLINGS

LOCATION:	FWD	CENTER	AFT
LENGTH:	60 FT	121.5 FT	61.5 FT

PERFORMANCE DATA

TIME:	
GREEN LIGHT TO FIRST MOTION	3.68 SEC
FIRST MOTION TO EXTRACTION RELEASE	1.12 SEC
FIRST MOTION TO TIP OFF OF FWD PLATFORM	1.67 SEC
GREEN LIGHT TO IMPACT	-
EXTRACTION VELOCITY	40 FPS
ROTATION:	
ANGLE AT TIP OFF:	
PLATFORM REF PLANE	-17.3^{o}
FWD PLATFORM	-9.8^{o}
ANGLE BETWEEN PLATFORMS:	
MAX. POS ANGLE	0^{o}
MAX. NEG ANGLE	-14.2^{o}
PLATFORM REF PLANE MAX. ANGLE	-58.5^{o}

DESCENT:

TIME FROM TIPOFF TO FULL CANOPY . . . . 11.8 SEC

TIME FROM TIPOFF TO ZERO FORWARD VELOCITY. . . . . 8.0 SEC

TIME FROM TIPOFF TO STABLE RATE OF DESCENT . . . . 13 SEC

ALTITUDE LOSS TO REACH VERT. VELOCITY OF 28.5 FPS . 927 FT

VERTICAL VELOCITY AT IMPACT . . . . 27 FPS

HORIZONTAL VELOCITY AT IMPACT . . . . 17 FPS

AVERAGE DESCENT RATE . . . . 27 FPS

INSTRUMENTED DATA

COMPRESSION LINK LOADS:

	PEAK	STEADY STATE
RIGHT SIDE:	-	-
LEFT SIDE:	-	-

TRUSS LOADS, PEAK

LOCATION:	FWD	AFT
RIGHT SIDE:	-	-
LEFT SIDE:	-	-

RAIL LOADS, PEAK

LOCATION:	FWD	AFT
RIGHT SIDE:	-	-
LEFT SIDE:	-	-

SLING LOADS, PEAK

LOCATION:	FWD	CENTER	AFT
RIGHT SIDE:	11,235 LB		2,090 LB
LEFT SIDE:	-		3,076 LB

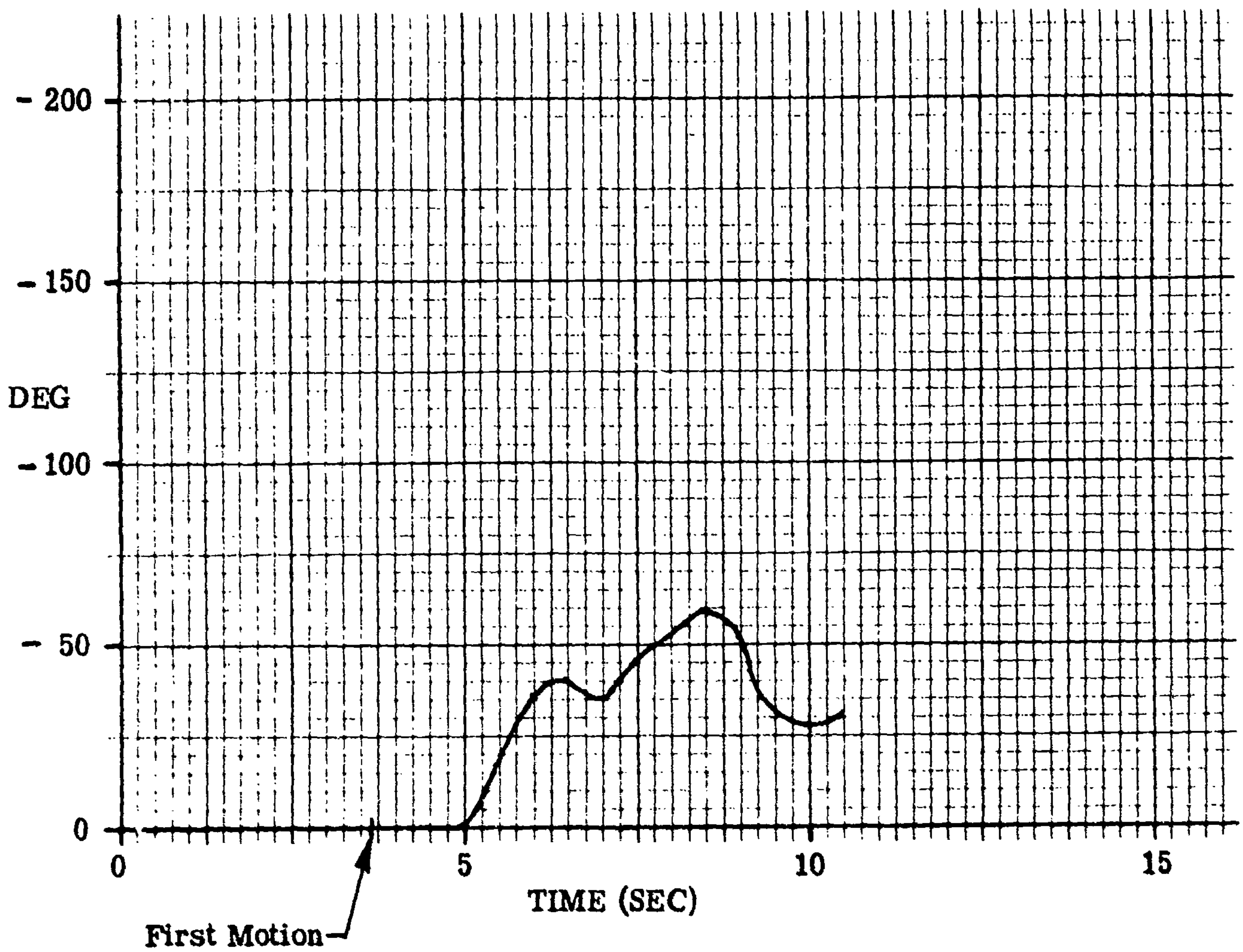


Figure 23. Platform Ref. Plane Angle vs. Time, ACES Drop #3

DROP #4

This was a two-platform drop configuration utilizing two 12-foot platforms. The respective platform loads were 5,200 lb on the forward and 12,000 lb on the aft platform. The orifices in the hydraulic lines were 0.070 in. diameter. The center of gravity was aft of center at 61 percent of the assembled length. The load-transfer actuator was installed on the aft platform. Line bags were used to house the forward and aft suspension slings. The strain links that monitor the sling loads were all mounted to the platform trusses. This was done to eliminate routing of the lead wires up the suspension slings where they were often broken due to a rough treatment during parachute deployment.

Extraction and exit from the aircraft was good. At tip-off the platform reference plane angle was -16.1^{0} and rotating clockwise. Due to the heavy aft load and the light forward load the platform assembly continued a rapid clockwise rotation. Wind loads on the platform assembly aided this clockwise rotation and the assembly reached a maximum of -234.5^{0} before counter clockwise rotation began. Fortunately the aft suspension slings laid inside the platform trusses which prevented them from going below the platform. During these rapid rotations one of the battery packs was thrown off which stopped transmissions from one of the telemetery packages. The load stabilized nicely and overall performance was satisfactory. As the platform assembly approached the ground, the hang of the platforms was low on the ends and high at the hinge point. The assembly landed on level ground but the hinge joint was overloaded at impact and the bolts that held the truss end weldment to the rail failed. This damage was easily repaired. Instrumentation was poor due to the loss of battery pack but usable data were obtained on the loads in the truss and rails.

DROP DATA TEST NO. 4

DATE	11/26/79
TIME	2:30 PM
WIND VELOCITY	12 TO 15 MPH
WIND DIRECTION	240°
AIRCRAFT	C-130
A/C VELOCITY	130 KTS
A/C HEADING	206°
A/C ALTITUDE	1500 FT AGL

PLATFORM CONFIGURATION

NO. OF PLATFORMS 2

ARRANGEMENT:	FWD	AFT
LENGTH:	12 FT	12 FT
WEIGHT:	5,200 LB	12,000 LB

LENGTH OF PLATFORM ASSY.	25.33 FT
C.G. LOCATION FROM FWD END	15.53 FT
PERCENTAGE FROM FWD END	61%
EXTRACTED WEIGHT	18,700 LB
HYDRAULIC CYLINDER ORIFICE DIAMETER	0.070 IN.

RIGGING DATA

PARACHUTES:

EXTRACTION	28' RS
NO. OF CHUTES	1

RECOVERY	G-11A
NO. OF CHUTES	5
EXTRACTION LINE LENGTH	60 FT
EXTRACTION RELEASE:	
TYPE	35 K
LOCATION FROM FWD EDGE OF PLATFORM ASSY	18.75 FT
PARACHUTE RELEASE	M-2

SUSPENSION SLINGS:

LOCATION:	FWD	CENTER	AFT
LENGTH:	61.5 FT	121.5 FT	80 FT

PERFORMANCE DATA

TIME:	
GREEN LIGHT TO FIRST MOTION	3.37 SEC
FIRST MOTION TO EXTRACTION RELEASE	1.10 SEC
FIRST MOTION TO TIP OFF OF FWD PLATFORM	1.56 SEC
GREEN LIGHT TO IMPACT	53.73 SEC
EXTRACTION VELOCITY	30 FPS
ROTATION:	
ANGLE AT TIP OFF:	
PLATFORM REF PLANE	16.1°
FWD PLATFORM	-4.8°
ANGLE BETWEEN PLATFORMS:	
MAX. POS ANGLE	0°
MAX. NEG ANGLE	24°
PLATFORM REF PLANE MAX. ANGLE	-234.5°

DESCENT:

TIME FROM TIPOFF TO FULL CANOPY	10.4 SEC
TIME FROM TIPOFF TO ZERO FORWARD VELOCITY	6.6 SEC
TIME FROM TIPOFF TO STABLE RATE OF DESCENT	11.4 SEC
ALTITUDE LOSS TO REACH VERT. VELOCITY OF 28.5 FPS	763 FT
VERTICAL VELOCITY AT IMPACT	23 FPS
HORIZONTAL VELOCITY AT IMPACT	20 FPS
AVERAGE DESCENT RATE	20 FPS

INSTRUMENTED DATA

COMPRESSION LINK LOADS:

	PEAK	STEADY STATE
RIGHT SIDE:	-	-
LEFT SIDE:	-	-

TRUSS LOADS, PEAK

LOCATION:	FWD	AFT
RIGHT SIDE:	17,916 LB	19,708 LB
LEFT SIDE:	17,916 LB	15,228 LB

RAIL LOADS, PEAK

LOCATION:	FWD	AFT
RIGHT SIDE:	-	-
LEFT SIDE:	10,384 LB	11,800 LB

SLING LOADS, PEAK

LOCATION:	FWD	CENTER	AFT
RIGHT SIDE:	-	-	-
LEFT SIDE:	-	-	-

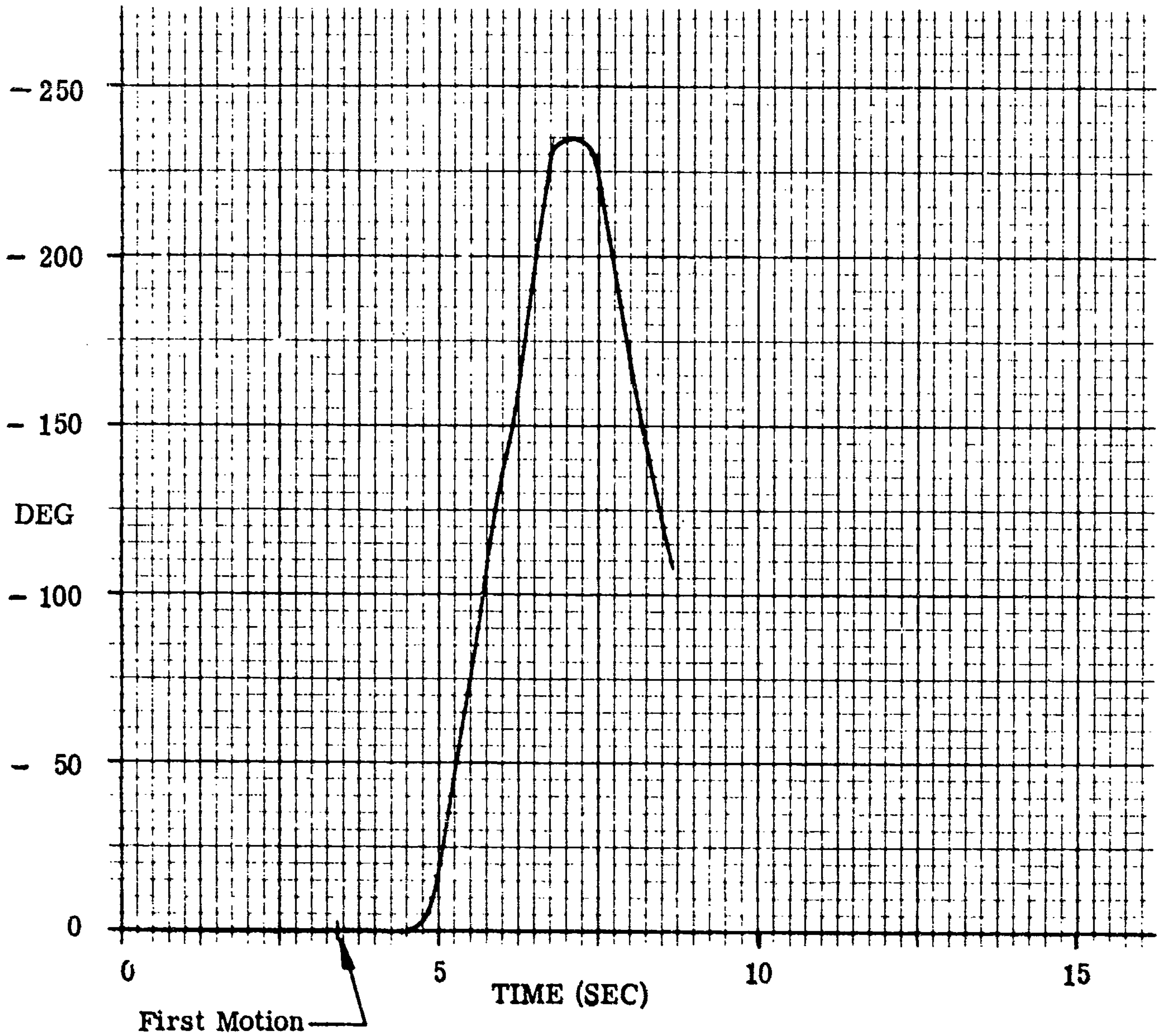


Figure 24. Platform Ref. Plane Angle vs. Time, ACES Drop #4

DROP #5

This was a two-platform drop configuration utilizing a 16-foot platform in the forward location and a 12-foot platform aft. The respective platform loads were 6,500 lb on the forward and 5,575 lb on the aft platform. The orifice in the hydraulic lines remained at 0.070 in. diameter. The center of gravity was aft of center at 51 percent of the assembled length. The load-transfer actuator was installed on the aft platform. Line bags were used on the four corner suspension slings. The strain links for monitoring the suspension sling loads were mounted to the platform truss.

Extraction and exit from the aircraft were very good. At tip-off the platform reference plane angle was -14.2° and rotating clockwise. It continued rotating to a maximum of -114.5° before the aft suspension slings became taut at 2.03 seconds after tip-off and reversed its direction. The instrumentation functioned well on this test and the following data was among the data obtained. The aft suspension sling load peaked at 4,641 lb causing a peak load in the compression links of 29,677 lb, a peak truss load of 25,012 lb and a peak rail load of 26,432 lb. Overall performance of the system was excellent and landing was accomplished without incident.

DROP DATA TEST NO. 5

DATE	11/30/79
TIME	11:00 AM
WIND VELOCITY	8 TO 12 MPH
WIND DIRECTION	230°
AIRCRAFT	C-130
A/C VELOCITY	130 KTS
A/C HEADING	206°
A/C ALTITUDE	1500 FT AGL

PLATFORM CONFIGURATION

NO. OF PLATFORMS 2

ARRANGEMENT:	FWD	AFT
LENGTH:	16 FT	12 FT
WEIGHT:	6,500 LB	5,575 LB

LENGTH OF PLATFORM ASSY.	29.42 FT
C.G. LOCATION FROM FWD END	15.12 FT
PERCENTAGE FROM FWD END	51%
EXTRACTED WEIGHT	12,825 LB
HYDRAULIC CYLINDER ORIFICE DIAMETER	0.070 IN.

RIGGING DATA

PARACHUTES:

EXTRACTION	22' RS
NO. OF CHUTES	1

RECOVERY G-11A

NO. OF CHUTES 3

EXTRACTION LINE LENGTH . . . . 60 FT

EXTRACTION RELEASE:

TYPE . . . . 35 K

LOCATION FROM FWD EDGE OF PLATFORM ASSY . . . . 22.83 FT

PARACHUTE RELEASE M-2

SUSPENSION SLINGS:

LOCATION:	FWD	CENTER	AFT
LENGTH:	60 FT	120 FT	60 FT

PERFORMANCE DATA

TIME:

GREEN LIGHT TO FIRST MOTION . . . . 3.13 SEC

FIRST MOTION TO EXTRACTION RELEASE . . . . 1.14 SEC

FIRST MOTION TO TIP OFF OF FWD PLATFORM . . . . 1.81 SEC

GREEN LIGHT TO IMPACT . . . . 59.92 SEC

EXTRACTION VELOCITY . . . . 32.48 SEC

ROTATION:

ANGLE AT TIP OFF:

PLATFORM REF PLANE . . . . -14.2^{o}

FWD PLATFORM . . . . -3.1^{o}

ANGLE BETWEEN PLATFORMS:

MAX. POS ANGLE . . . . 0^{o}

MAX. NEG ANGLE . . . . -26^{o}

PLATFORM REF PLANE MAX. ANGLE . . . . -114.5^{o}

DESCENT:

TIME FROM TIPOFF TO FULL CANOPY	8.6 SEC
TIME FROM TIPOFF TO ZERO FORWARD VELOCITY.	6.7 SEC
TIME FROM TIPOFF TO STABLE RATE OF DESCENT	10.0 SEC
ALTITUDE LOSS TO REACH VERT. VELOCITY OF 28.5 FPS .	608 FT
VERTICAL VELOCITY AT IMPACT	18 FPS
HORIZONTAL VELOCITY AT IMPACT	29 FPS
AVERAGE DESCENT RATE	23 FPS

INSTRUMENTED DATA

COMPRESSION LINK LOADS:

	PEAK	STEADY STATE
RIGHT SIDE:	18,611 LB	25,012 LB
LEFT SIDE:	30,829 LB	29,677 LB

TRUSS LOADS, PEAK

LOCATION:	FWD	AFT
RIGHT SIDE:	4,479 LB	21,499 LB
LEFT SIDE:	19,708 LB	-

RAIL LOADS, PEAK

LOCATION:	FWD	AFT
RIGHT SIDE:	26,432 LB	14,160 LB
LEFT SIDE:	-	13,688 LB

SLING LOADS, PEAK

LOCATION:	FWD	CENTER	AFT
RIGHT SIDE:	6,984 LB	-	4,641 LB
LEFT SIDE:	7,275 LB	1,615 LB	-

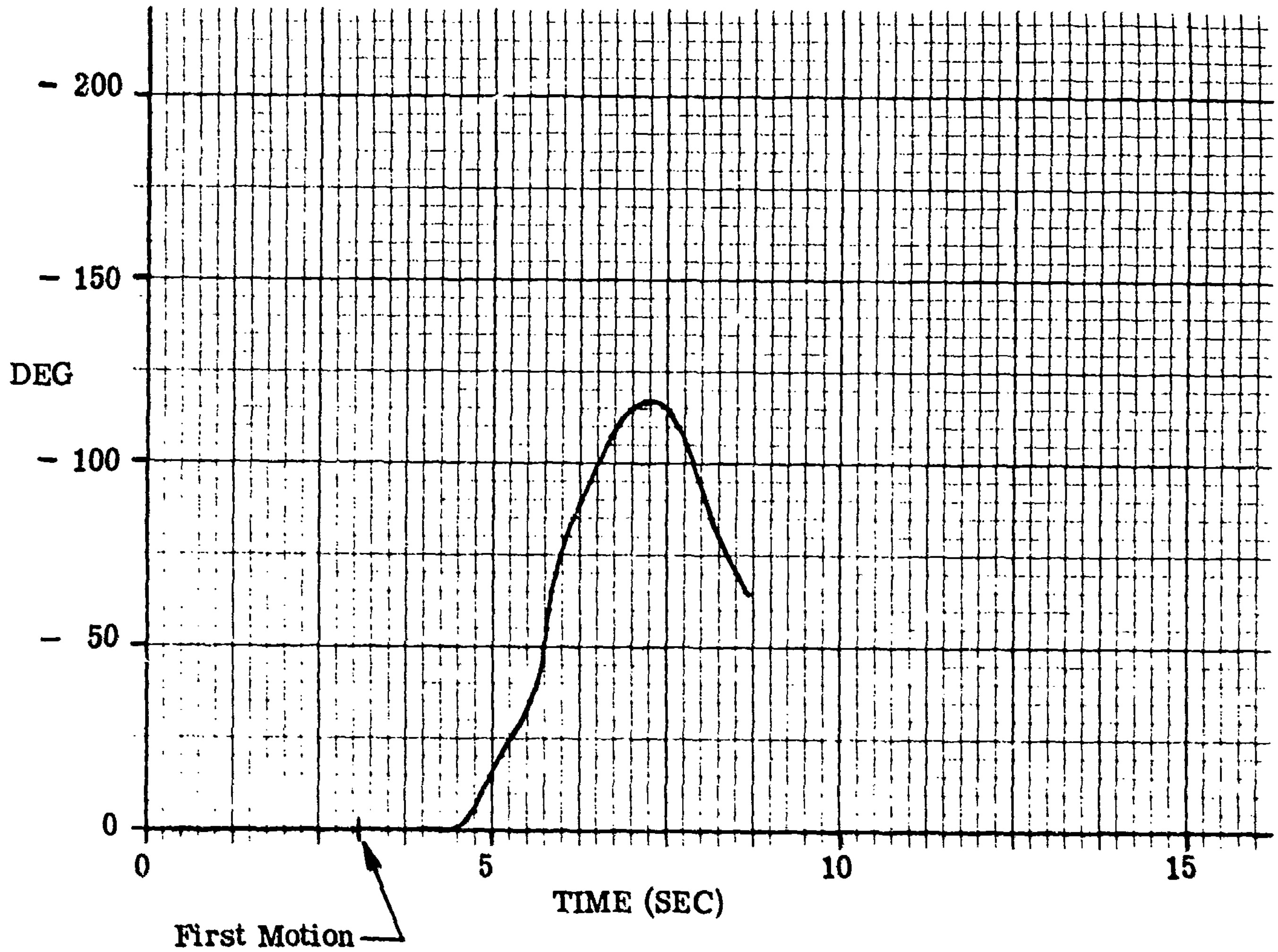


Figure 25. Platform Ref. Plane Angle vs. Time, ACES Drop #5

DROP #6

This was a two-platform drop configuration utilizing a 20-foot platform in the forward location and a 12-foot platform aft. The respective platform loads were 7,500 lb on the forward platform and 5,575 lb on the aft platform. The orifice in the hydraulic lines was 0.070 in. diameter. The center of gravity was aft of center at 53 percent of the assembled platform length. The load-transfer actuator was installed on the aft platform. Line bags were used on the four corners suspension slings and the strain links for monitoring the loads in this sling were mounted to the platform trusses.

Extraction and exit from the aircraft was very good. At tip-off the platform reference plane angle was -14.1^{0} and rotating clockwise. It continued rotating to a maximum of -133^{0} before the aft slings became loaded at 2.14 seconds after tip-off and arrested the rotation and reversed it to the opposite direction. The load in the aft suspension slings reached a peak value of 7,240 lb in stopping this rotation. At 4.94 seconds after tip-off, loads in the forward and aft suspension slings peaked simultaneously causing a peak load in the compression links of 57,854 lb. A maximum steady state load of 38,570 lb was measured in the compression links. Peak loads measured in the truss and rail were 30,367 and 23,081 lb respectively. Landing was without incident.

DROP DATA TEST NO. 6

DATE	1/17/80
TIME	2:21 PM
WIND VELOCITY	-
WIND DIRECTION	-
AIRCRAFT	C-130
A/C VELOCITY	130 KTS
A/C HEADING	206°
A/C ALTITUDE	1500 FT AGL

PLATFORM CONFIGURATION

NO. OF PLATFORMS 2

ARRANGEMENT:	FWD	AFT
LENGTH:	20 FT	12 FT
WEIGHT:	7,500 LB	6,575 LB

LENGTH OF PLATFORM ASSY.	33.5 FT
C.G. LOCATION FROM FWD END	17.70 FT
PERCENTAGE FROM FWD END	53%
EXTRACTED WEIGHT	14,075 LB
HYDRAULIC CYLINDER ORIFICE DIAMETER	0.070 IN.

RIGGING DATA

PARACHUTES:

EXTRACTION	28' RS
NO. OF CHUTES	1

RECOVERY G-11A

NO. OF CHUTES 4

EXTRACTION LINE LENGTH . . . . 60 FT

EXTRACTION RELEASE

TYPE . . . . 35 K

LOCATION FROM FWD EDGE OF PLATFORM ASSY . . . . 26.92 FT

PARACHUTE RELEASE M-2

SUSPENSION SLINGS

LOCATION:	FWD	CENTER	AFT
LENGTH:	60 FT	120 FT	60 FT

PERFORMANCE DATA

TIME:

GREEN LIGHT TO FIRST MOTION . . . . 3.35 SEC

FIRST MOTION TO EXTRACTION RELEASE . . . . 0.80 SEC

FIRST MOTION TO TIP OFF OF FWD PLATFORM . . . . 1.41 SEC

GREEN LIGHT TO IMPACT . . . . 59.60 SEC

EXTRACTION VELOCITY . . . . 50 FPS

ROTATION:

ANGLE AT TIP OFF:

PLATFORM REF PLANE . . . . -14.1°

FWD PLATFORM . . . . -4.6°

ANGLE BETWEEN PLATFORMS:

MAX. POS ANGLE . . . . 0°

MAX. NEG ANGLE . . . . - 25.7°

PLATFORM REF PLANE MAX. ANGLE . . . . - 133°

DESCENT:

TIME FROM TIPOFF TO FULL CANOPY . . . . 15.0 SEC

TIME FROM TIPOFF TO ZERO FORWARD VELOCITY. . . . . 5.6 SEC

TIME FROM TIPOFF TO STABLE RATE OF DESCENT . . . . 16.2 SEC

ALTITUDE LOSS TO REACH VERT. VELOCITY OF 28.5 FPS . 605 FT

VERTICAL VELOCITY AT IMPACT . . . . 22 FPS

HORIZONTAL VELOCITY AT IMPACT . . . . 22 FPS

AVERAGE DESCENT RATE . . . . 23 FPS

INSTRUMENTED DATA

COMPRESSION LINK LOADS:

	PEAK	STEADY STATE
RIGHT SIDE:	40,360 LB	27,540 LB
LEFT SIDE:	57,854 LB	38,570 LB

TRUSS LOADS, PEAK

LOCATION:	FWD	AFT
RIGHT SIDE:	29,024 LB	18,364 LB
LEFT SIDE:	30,367 LB	-

RAIL LOADS, PEAK

LOCATION:	FWD	AFT
RIGHT SIDE:	-	15,434 LB
LEFT SIDE:	23,081 LB	20,768 LB

SLING LOADS, PEAK

LOCATION:	FWD	CENTER	AFT
RIGHT SIDE:	11,653 LB	1,610 LB	8,310 LB
LEFT SIDE:	11,009 LB	1,538 LB	6,688 LB

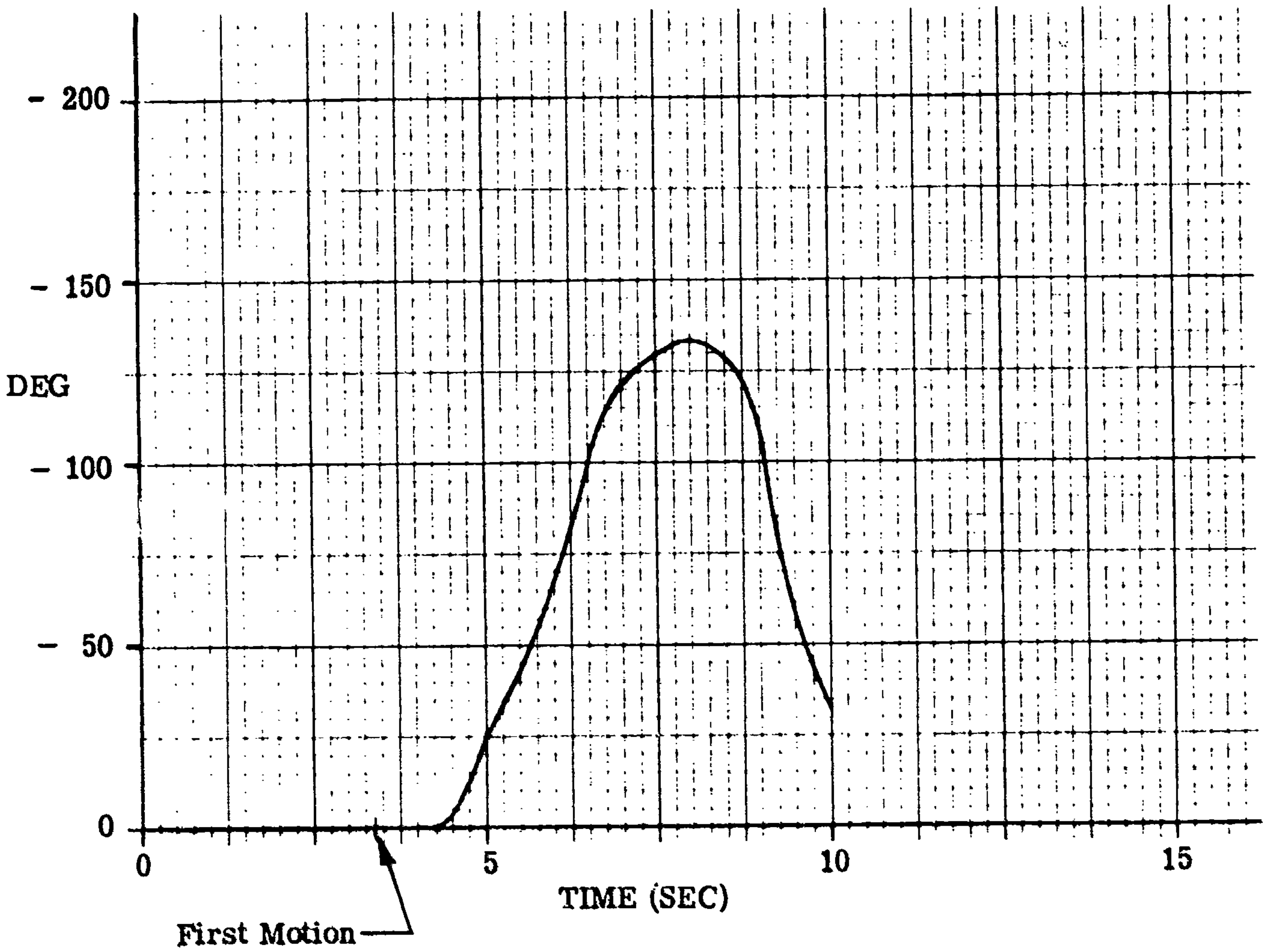


Figure 26. Platform Ref. Plane Angle vs. Time, ACES Drop #6

DROP #7

This was a two-platform drop composed of a 16 and a 20-foot platform, both carrying light loads. The 20-foot platform was in the forward location. The center of gravity was at the 49 percent mark or near the center of the assembly. The load-transfer release was on the aft platform. An 0.070-in. diameter orifice was used in the hydraulic control cylinders. This system performed well. The assembly load rotated about -65 degrees (in the negative or clockwise direction) when the forward suspension links became taut at 1.67 seconds after tip-off. This initial sling load was relatively light. The assembly continued to rotate to a maximum negative angle of -102.5 degrees at which point the aft suspension slings became taut at 2.37 seconds after tip-off. The pull of the aft slings reversed the direction of rotation and the forward sling picked up load again at about 4.0 seconds after tip-off. The load landed safely but sheared two attachment bolts that were readily replaced.

The instrumentation on this test functioned well. The measured loads were in the moderate range. The compression link loads were 40,838 lbs. peak and 36,493 lb steady state, indicating a very well-behaved system.

DROP DATA TEST NO. 7

DATE 1/22/80

TIME . . . . 10:30 AM

WIND VELOCITY . . . . 8 MPH

WIND DIRECTION . . . . 300^{o}

AIRCRAFT C-130

A/C VELOCITY . . . . 130 KTS

A/C HEADING . . . . 206^{o}

A/C ALTITUDE . . . . 1500 FT AGL

PLATFORM CONFIGURATION

NO. OF PLATFORMS 2

ARRANGEMENT:	FWD	AFT
LENGTH:	20 FT	16 FT
WEIGHT:	7,500 LB	5,600 LB

LENGTH OF PLATFORM ASSY. . . . . 37.58 FT

C.G. LOCATION FROM FWD END . . . . 18.37 FT

PERCENTAGE FROM FWD END 49%

EXTRACTED WEIGHT . . . . 14,100 LB

HYDRAULIC CYLINDER ORIFICE DIAMETER . . . . 0.070 IN.

RIGGING DATA

PARACHUTES:

EXTRACTION . . . . 28' RS

NO. OF CHUTES 1

RECOVERY G-11A

NO. OF CHUTES 4

EXTRACTION LINE LENGTH . . . . 60 FT

EXTRACTION RELEASE:

TYPE . . . . 35 K

LOCATION FROM FWD EDGE OF PLATFORM ASSY . . . . 28.83 FT

PARACHUTE RELEASE M-2

SUSPENSION SLINGS

LOCATION:	FWD	CENTER	AFT
LENGTH:	60 FT	120 FT	61.5 FT

PERFORMANCE DATA

TIME:

GREEN LIGHT TO FIRST MOTION . . . . 3.89 SEC

FIRST MOTION TO EXTRACTION RELEASE . . . . 0.88 SEC

FIRST MOTION TO TIP OFF OF FWD PLATFORM . . . . 1.56 SEC

GREEN LIGHT TO IMPACT . . . . 61.87 SEC

EXTRACTION VELOCITY . . . . 35.78 FPS

ROTATION:

ANGLE AT TIP OFF:

PLATFORM REF PLANE . . . . -14.2^{o}

FWD PLATFORM . . . . -2.4^{o}

ANGLE BETWEEN PLATFORMS:

MAX. POS ANGLE . . . . 0^{o}

MAX. NEG ANGLE . . . . -26.8^{o}

PLATFORM REF PLANE MAX. ANGLE . . . . 102.5^{o}

DESCENT:

TIME FROM TIPOFF TO FULL CANOPY	9.0 SEC
TIME FROM TIPOFF TO ZERO FORWARD VELOCITY.	8.4 SEC
TIME FROM TIPOFF TO STABLE RATE OF DESCENT	9.8 SEC
ALTITUDE LOSS TO REACH VERT. VELOCITY OF 28.5 FPS .	865 FT
VERTICAL VELOCITY AT IMPACT	24 FPS
HORIZONTAL VELOCITY AT IMPACT	18 FPS
AVERAGE DESCENT RATE	22 FPS

INSTRUMENTED DATA

COMPRESSION LINK LOADS:

	PEAK	STEADY STATE
RIGHT SIDE:	40,838 LB	36,493 LB
LEFT SIDE:	27,000 LB	31,077 LB

TRUSS LOADS, PEAK

LOCATION:	FWD	AFT
RIGHT SIDE:	22,395 LB	20,603 LB
LEFT SIDE:	19,708 LB	19,708 LB

RAIL LOADS, PEAK

LOCATION:	FWD	AFT
RIGHT SIDE:	25,488 LB	16,048 LB
LEFT SIDE:	15,576 LB	13,688 LB

SLING LOADS, PEAK

LOCATION:	FWD	CENTER	AFT
RIGHT SIDE:	5,481 LB	2,330 LB	5,434 LB
LEFT SIDE:	5,208 LB	2,550 LB	5,243 LB

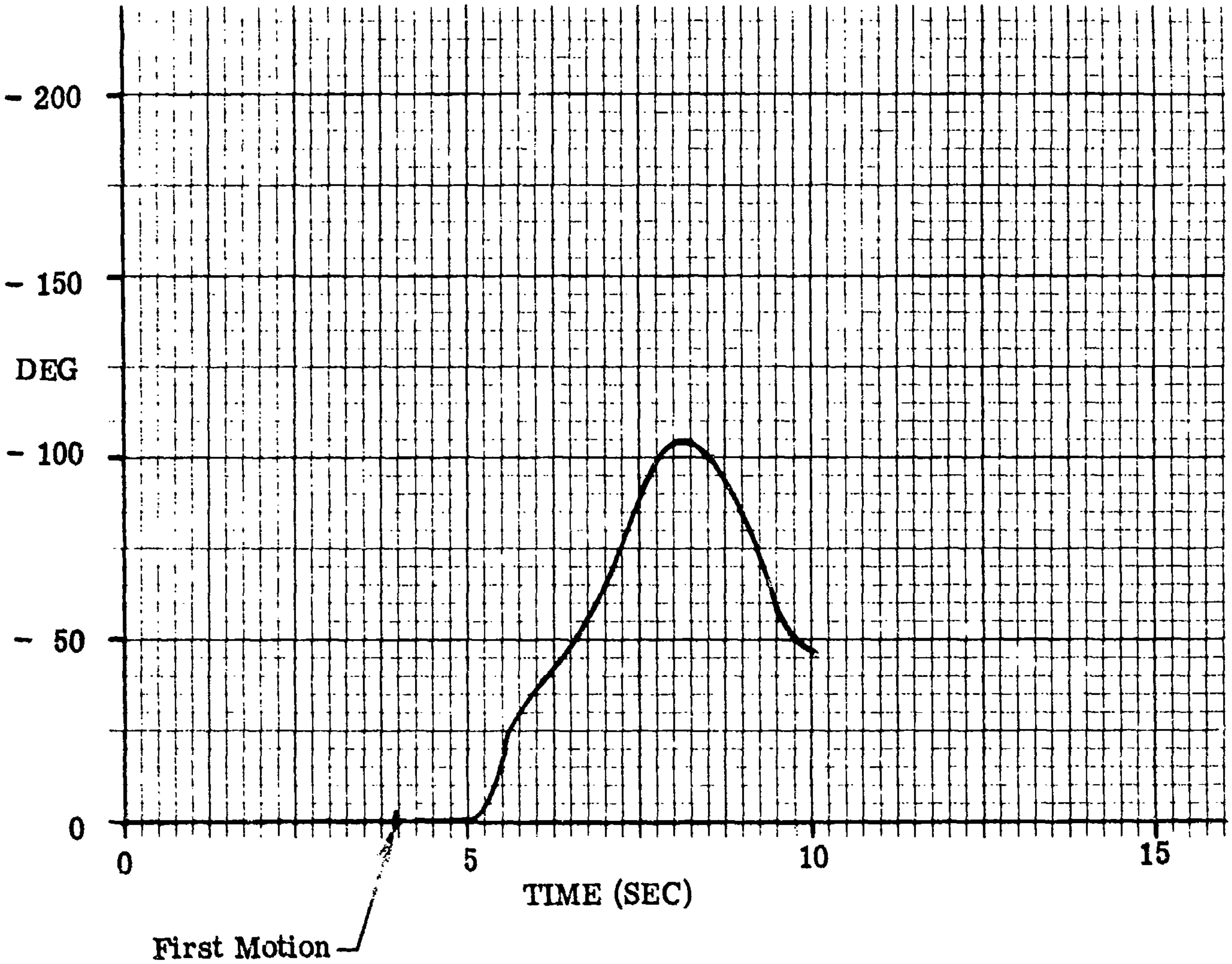


Figure 27. Platform Ref. Plane Angle vs. Time, ACES Drop #7

DROP #8

This was the first of the three platform configuration tests. Three 12-foot platforms were linked each carrying a light load. The center of gravity was near the center of the load at the 53 percent mark. The extraction force release mechanism was installed on the center platform. An 0.070-in. diameter orifice was used in the hydraulic control.

This was a satisfactory drop, but negative rotation in the tip-off direction was high peaking at -193.5 degrees at about 4.0 seconds after tip-off. The release for the extraction force transfer, being installed on the center platform, delayed deployment of the recovery parachutes a few milliseconds which may have contributed to this large amount of assembly rotation. Telemetry performance was poor on this test and usable data on only a few channels was obtained.

DROP DATA TEST NO. 8

DATE	1/25/80
TIME	1:28 PM
WIND VELOCITY	5 MPH
WIND DIRECTION	145^{o}
AIRCRAFT	C-130
A/C VELOCITY	130 KTS
A/C HEADING	206^{o}
A/C ALTITUDE	1500 FT AGL

PLATFORM CONFIGURATION

NO. OF PLATFORMS 3

ARRANGEMENT:	FWD	CENTER	AFT
LENGTH:	12 FT	12 FT	12 FT
WEIGHT:	4,800 LB	5,600 LB	5,400 LB

LENGTH OF PLATFORM ASSY.	38.66 FT
C.G. LOCATION FROM FWD END	20.55 FT
PERCENTAGE FROM FWD END	53%
EXTRACTED WEIGHT	16,800 LB
HYDRAULIC CYLINDER ORIFICE DIAMETER	0.070 IN.

RIGGING DATA

PARACHUTES:

EXTRACTION	28' RS
NO. OF CHUTES	1

RECOVERY G-11A

NO. OF CHUTES 4

EXTRACTION LINE LENGTH . . . . 60 FT

EXTRACTION RELEASE

TYPE . . . . 35 K

LOCATION FROM FWD EDGE OF PLATFORM ASSY . . . . 18.58 FT

PARACHUTE RELEASE M-2

SUSPENSION SLINGS

LOCATION:	FWD	CENTER FWD	CENTER AFT	AFT
LENGTH:	60 FT	120 FT	120 FT.	60 FT

PERFORMANCE DATA

TIME:

GREEN LIGHT TO FIRST MOTION . . . . 3.72 SEC

FIRST MOTION TO EXTRACTION RELEASE . . . . 1.35 SEC

FIRST MOTION TO TIP OFF OF FWD PLATFORM . . . . 1.74 SEC

GREEN LIGHT TO IMPACT . . . . 41.47 SEC

EXTRACTION VELOCITY . . . . 47.72 FPS

ROTATION:

ANGLE AT TIP OFF:

PLATFORM REF PLANE . . . . -11.2^{o}

FWD PLATFORM . . . . -2.1^{o}

ANGLE BETWEEN PLATFORMS:

LOCATION:	FWD HINGE LINE		AFT HINGE LINE
MAX. POS. ANGLE	3^{o}	. . . . .	0^{o}
MAX. NEG. ANGLE	-8^{o}	. . . . .	-24^{o}

PLATFORM REF. PLANE MAX. ANGLE . . . . -193.5^{o}

DESCENT:

TIME FROM TIPOFF TO FULL CANOPY . . . . 13.3 SEC

TIME FROM TIPOFF TO ZERO FORWARD VELOCITY. . . . . 7.0 SEC

TIME FROM TIPOFF TO STABLE RATE OF DESCENT . . . . 14.5 SEC

ALTITUDE LOSS TO REACH VERT. VELOCITY OF 28.5 FPS . 813 FT

VERTICAL VELOCITY AT IMPACT . . . . 26 FPS

HORIZONTAL VELOCITY AT IMPACT . . . . 14 FPS

AVERAGE DESCENT RATE . . . . 24 FPS

INSTRUMENTED DATA

COMPRESSION LINK LOADS:

FWD HINGE LINE LOCATION:

	PEAK	STEADY STATE
RIGHT SIDE	—	—
LEFT SIDE	—	—

AFT HINGE LINE LOCATION:

	PEAK	STEADY STATE
RIGHT SIDE:	—	—
LEFT SIDE:	—	—

TRUSS LOADS, PEAK

PLATFORM:	FWD	CENTER		AFT
LOCATION:	AFT	FWD	AFT	FWD
RIGHT SIDE:	-	35,832 LB	44,790 LB	25,978 LB
LEFT SIDE:	26,874 LB	26,874 LB	44,790 LB	-

RAIL LOADS, PEAK

PLATFORM	FWD	CENTER		AFT
LOCATION:	AFT	FWD	AFT	FWD
RIGHT SIDE:	47,200 LB	47,200 LB	47,200 LB	23,600 LB
LEFT SIDE:	23,600 LB	25,960 LB	-	-

SLING LOADS, PEAK

PLATFORM	FWD	CENTER		AFT
LOCATION:	AFT	FWD	AFT	FWD
RIGHT SIDE:	13,000 LB	1,550 LB	1,273 LB	10,500 LB
LEFT SIDE:	13,000 LB	1,697 LB	1,697 LB	16,500 LB

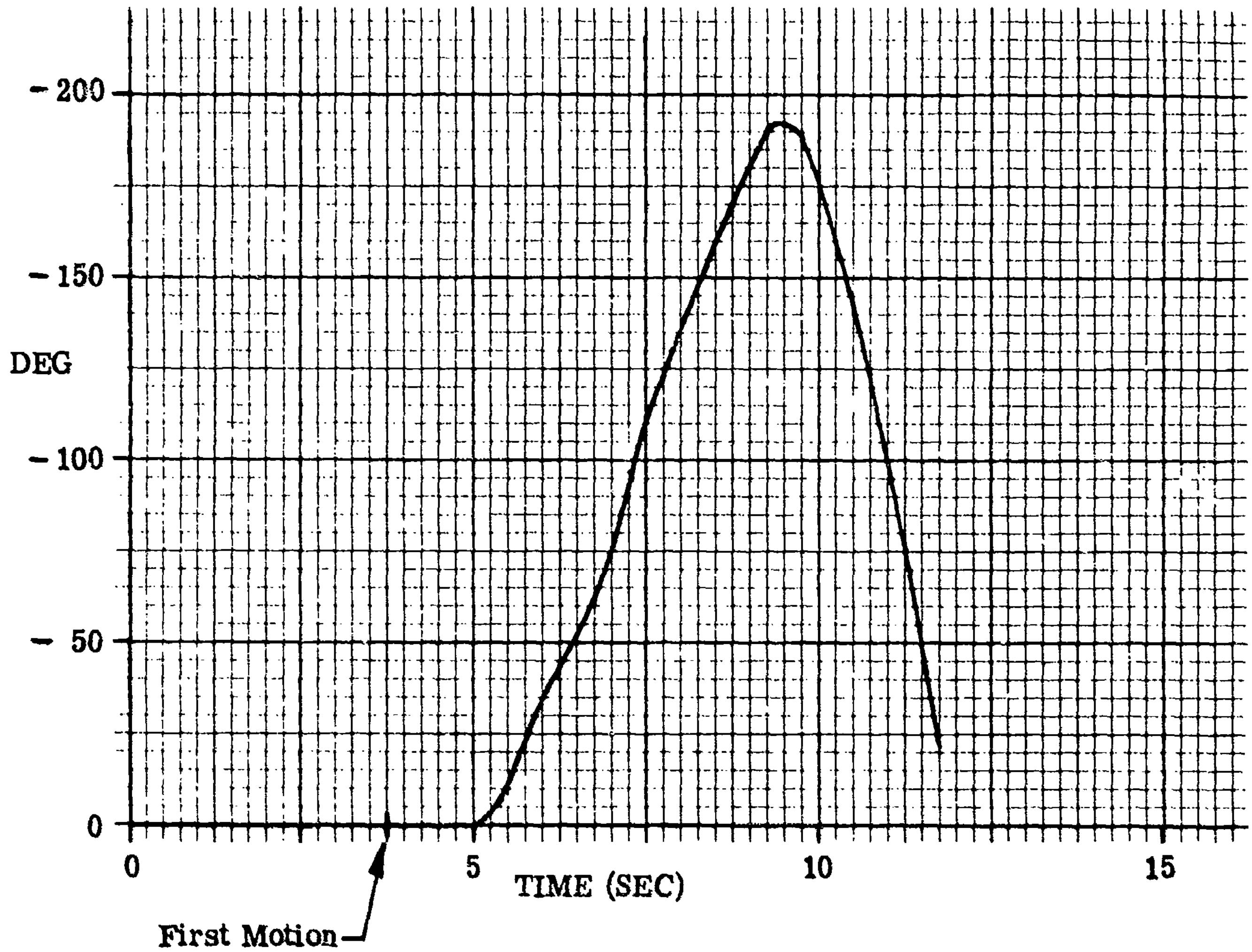


Figure 28. Platform Ref. Plane Angle vs. Time, ACES Drop #8

DROP #9

This was a three-platform test configuration using 12-foot platforms. The forward platform was heavily loaded at 11,870 lb, but the other platforms carried light loads of 5,600 lb in the middle and 5,400-lb on the aft platform. The center of gravity was forward of the geometric center at 41.2 percent of the assembled length. The extraction force release mechanism was installed on the aft platform. An 0.070-in. diameter orifice was used in the hydraulic control device.

This system functioned very well up until 10.97 seconds after tip-off when the M-2 parachute release functioned in mid air resulting in a high velocity impact and extensive damage to the equipment. The forward suspension slings became taut at 1.59 seconds after tip-off. The aft suspension slings were loaded at 3.17 seconds after tip-off and reversed the direction of rotation at a peak value of -70 degrees. The moderate sail area aft of the C.G. may have been helpful in limiting this rotation.

The instrumentation functioned satisfactorily on this test. The peak and steady state compression link loads were 65,000 and 57,000 lb respectively.

One 12-foot platform assembly was reconstructed from parts from the wreckage. This was combined with the 16 and 20-foot platforms to continue the test program.

DROP DATA TEST NO. 9

DATE	1/31/80
TIME	10:35 AM
WIND VELOCITY	-
WIND DIRECTION	-
AIRCRAFT	C-130
A/C VELOCITY	130 KTS
A/C HEADING	206°
A/C ALTITUDE	1500 FT AGL

PLATFORM CONFIGURATION

NO. OF PLATFORMS 3

ARRANGEMENT:	FWD	CENTER	AFT
LENGTH:	12 FT	12 FT	12 FT
WEIGHT:	11,870 LB	5,600 LB	5,400 LB

LENGTH OF PLATFORM ASSY.	38.66 FT
C.G. LOCATION FROM FWD END	15.95 FT
PERCENTAGE FROM FWD END	41%
EXTRACTED WEIGHT	24,370
HYDRAULIC CYLINDER ORIFICE DIAMETER	0.070 IN.

RIGGING DATA

PARACHUTES:

EXTRACTION	28' RS
NO. OF CHUTES	2

RECOVERY G-11A

NO. OF CHUTES 6

EXTRACTION LINE LENGTH . . . . 60 FT

EXTRACTION RELEASE

TYPE . . . . 35 K

LOCATION FROM FWD EDGE OF PLATFORM ASSY . . . . 32.08 FT

PARACHUTE RELEASE M-2

SUSPENSION SLINGS

LOCATION:	FWD	CENTER FWD	CENTER AFT	AFT
LENGTH:	60 FT	120 FT	121.5 FT	61.5 FT

PERFORMANCE DATA

TIME:

GREEN LIGHT TO FIRST MOTION . . . . 3.04 SEC

FIRST MOTION TO EXTRACTION RELEASE . . . . 1.04 SEC

FIRST MOTION TO TIP OFF OF FWD PLATFORM . . . . 1.97 SEC

GREEN LIGHT TO IMPACT . . . . 23.59 SEC

EXTRACTION VELOCITY . . . . 30.83 FPS

ROTATION:

ANGLE AT TIP OFF:

PLATFORM REF PLANE . . . . -27.5^{o}

FWD PLATFORM . . . . -12.1^{o}

ANGLE BETWEEN PLATFORMS:

LOCATION:	FWD HINGE LINE		AFT HINGE LINE
MAX. POS. ANGLE	-	. . . . .	-
MAX. NEG. ANGLE	-10^{o}	. . . . .	-29^{o}

PLATFORM REF. PLANE MAX. ANGLE . . . . -70^{o}

DESCENT:

TIME FROM TIPOFF TO FULL CANOPY . . . . -

TIME FROM TIPOFF TO ZERO FORWARD VELOCITY. . . . . -

TIME FROM TIPOFF TO STABLE RATE OF DESCENT . . . . -

ALTITUDE LOSS TO REACH VERT. VELOCITY OF 28.5 FPS . -

VERTICAL VELOCITY AT IMPACT . . . . -

HORIZONTAL VELOCITY AT IMPACT . . . . -

AVERAGE DESCENT RATE . . . . -

INSTRUMENTED DATA

COMPRESSION LINK LOADS:

FWD HINGE LINE LOCATION:

	PEAK	STEADY STATE
RIGHT SIDE	28,000 LB	28,000 LB
LEFT SIDE	65,000 LB	57,000 LB

AFT HINGE LINE LOCATION:

	PEAK	STEADY STATE
RIGHT SIDE:	35,000 LB	25,000 LB
LEFT SIDE:	27,000 LB	25,000 LB

TRUSS LOADS, PEAK

PLATFORM:	FWD	CENTER		AFT
LOCATION:	AFT	FWD	AFT	FWD
RIGHT SIDE:	18,812 LB	14,322 LB	15,228 LB	11,645 LB
LEFT SIDE:	29,561 LB	18,812 LB	13,437 LB	11,645 LB

RAIL LOADS, PEAK

PLATFORM	FWD	CENTER		AFT
LOCATION:	AFT	FWD	AFT	FWD
RIGHT SIDE:	11,800 LB	10,384 LB	-	9,440 LB
LEFT SIDE	13,688 LB	14,632 LB	10,856 LB	9,440 LB

SLING LOADS, PEAK

PLATFORM	FWD	CENTER		AFT
LOCATION:	AFT	FWD	AFT	FWD
RIGHT SIDE:	8,200 LB	3,479 LB	1,436 LB	4,200 LB
LEFT SIDE:	10,000 LB	3,662 LB	1,221 LB	4,700 LB

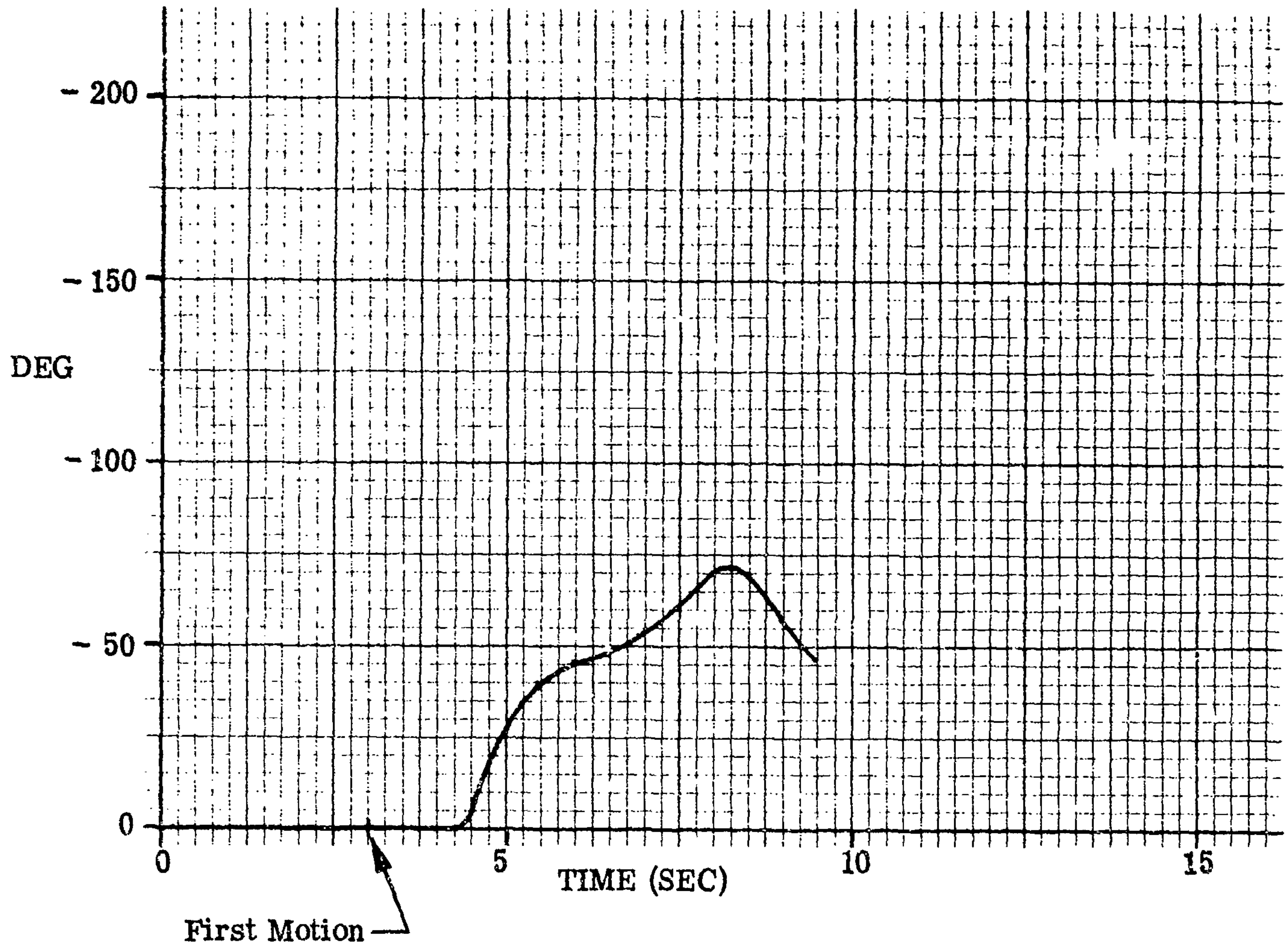


Figure 29. Platform Ref. Plane Angle vs. Time, ACES Drop #9

DROP #10

This was a three-platform drop using one each 20-foot, 16-foot and 12-foot platform. The 20-foot platform was forward in the aircraft and the 16-foot platform was in the center of the assembly. All three platforms carried light loads. This was the first test performed from a C-141 aircraft. The load-transfer release mechanism was on the aft platform. The center of gravity was aft of the geometric center at 54.1 percent of the assembled length. An 0.070-in. diameter orifice was used in the hydraulic controls.

This was a successful test, but some structural damage was incurred during the test that required some revision of the rail extension members. The forward suspension slings became taut at 1.19 seconds after tip-off. This was a substantial sling load of 5,500 lb which accelerated the tip-off or negative rotation and the aft suspension slings became taut at 2.02 seconds after tip-off. Negative rotation was stopped at 4.5 seconds after tip-off at a value of -159 degrees. The pull on these aft slings had increased to a value of about 8,000 lb and under this pull the assembly was rapidly accelerated in the positive direction. The forward suspension slings became taut again at 7.12 seconds after tip-off. The assembly was rotating at a velocity of about 60 degrees per second when these forward slings became taut. The sling loads peaked at about 13,000 lb causing a compression link load of about 80,000 lb. The angle between the forward and center platforms was about -20 degrees at the time the compression load peaked, and this combination of a high load and unfavorable angle resulted in failure of the rail extensions on the forward platform. The recovery parachutes were near full deployment by this time and were able to control the assembly so that a satisfactory recovery was effected. The ground winds were fairly brisk at touchdown and the assembly skidded 25 to 30 feet along the ground at touchdown. This caused some damage to the rail extension members between the center and aft platforms.

The platforms were repaired, and in accomplishing the repairs materials in the rail extensions were changed to increase the strength of the members.

DROP DATA TEST NO. 10

DATE 3/6/80

TIME . . . . 2:02 PM

WIND VELOCITY . . . . 13 MPH

WIND DIRECTION . . . . 165^{o}

AIRCRAFT C-141

A/C VELOCITY . . . . 150 KTS

A/C HEADING . . . . 206^{o}

A/C ALTITUDE . . . . 1500 FT AGL

PLATFORM CONFIGURATION

NO. OF PLATFORMS 3

ARRANGEMENT:	FWD	CENTER	AFT
LENGTH:	20 FT	16 FT	12 FT
WEIGHT:	7,600 LB	6,900 LB	6,429 LB

LENGTH OF PLATFORM ASSY. . . . . 51 FT

C.G. LOCATION FROM FWD END . . . . 27.59 FT

PERCENTAGE FROM FWD END 54%

EXTRACTED WEIGHT . . . . 22,179 LB

HYDRAULIC CYLINDER ORIFICE DIAMETER . . . . 0.070 IN.

RIGGING DATA

PARACHUTES:

EXTRACTION . . . . 28' RS

NO. OF CHUTES 1

RECOVERY G-11A

NO. OF CHUTES 5

EXTRACTION LINE LENGTH . . . . 120 FT

EXTRACTION RELEASE

TYPE . . . . 35 K

LOCATION FROM FWD EDGE OF PLATFORM ASSY . . . . 44.42 FT

PARACHUTE RELEASE . . . . 5,000 LB

SUSPENSION SLINGS

LOCATION:	FWD	CENTER FWD	CENTER AFT	AFT
LENGTH:	64.5 FT	120 FT	120 FT	63 FT

PERFORMANCE DATA

TIME:

GREEN LIGHT TO FIRST MOTION . . . . 4.75 SEC

FIRST MOTION TO EXTRACTION RELEASE . . . . 1.29 SEC

FIRST MOTION TO TIP OFF OF FWD PLATFORM . . . . 2.32 SEC

GREEN LIGHT TO IMPACT . . . . 48.59 SEC

EXTRACTION VELOCITY . . . . 41.08 FPS

ROTATION:

ANGLE AT TIP OFF:

PLATFORM REF PLANE . . . . -20.4^{o}

FWD PLATFORM . . . . -4.5^{o}

ANGLE BETWEEN PLATFORMS:

LOCATION:	FWD HINGE LINE		AFT HINGE LINE
MAX. POS. ANGLE	-	. . . . .	-
MAX. NEG. ANGLE	-27^{o}	. . . . .	-25.5^{o}

PLATFORM REF. PLANE MAX. ANGLE . . . . -158.8^{o}

DESCENT:

TIME FROM TIPOFF TO FULL CANOPY	18.0 SEC
TIME FROM TIPOFF TO ZERO FORWARD VELOCITY.	13.0 SEC
TIME FROM TIPOFF TO STABLE RATE OF DESCENT	18.6 SEC
ALTITUDE LOSS TO REACH VERT. VELOCITY OF 28.5 FPS .	687 FT
VERTICAL VELOCITY AT IMPACT	27 FPS
HORIZONTAL VELOCITY AT IMPACT	-
AVERAGE DESCENT RATE	22 FPS

INSTRUMENTED DATA

COMPRESSION LINK LOADS:

FWD HINGE LINE LOCATION:

	PEAK	STEADY STATE
RIGHT SIDE	34,000 LB	-
LEFT SIDE	80,000 LB	-

AFT HINGE LINE LOCATION:

	PEAK	STEADY STATE
RIGHT SIDE:	43,000 LB	-
LEFT SIDE:	75,000 LB	-

TRUSS LOADS, PEAK

PLATFORM:	FWD	CENTER		AFT
LOCATION:	AFT	FWD	AFT	FWD
RIGHT SIDE:	-	24,187 LB	27,770 LB	-
LEFT SIDE:	-	49,269 LB	38,519 LB	-

RAIL LOADS, PEAK

PLATFORM	FWD	CENTER		AFT
LOCATION:	AFT	FWD	AFT	FWD
RIGHT SIDE:	-	18,880 LB	14,160 LB	-
LEFT SIDE:	-	47,200 LB	47,200 LB	-

SLING LOADS, PEAK

PLATFORM	FWD	CENTER		AFT
LOCATION:	AFT	FWD	AFT	FWD
RIGHT SIDE:	5,500 LB	-	-	9,500 LB
LEFT SIDE:	13,000 LB	-	-	-

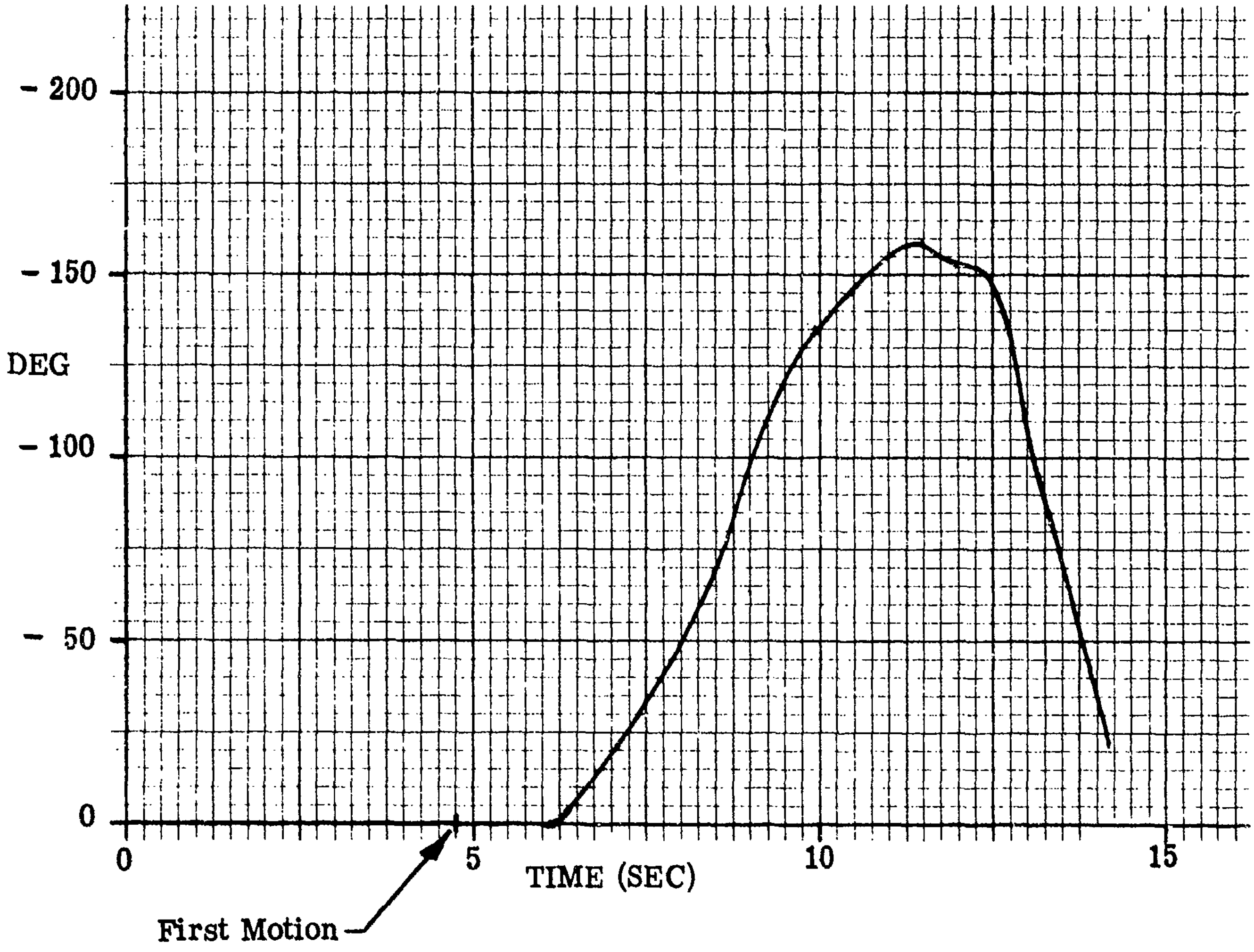


Figure 30. Platform Ref. Plane Angle vs. Time, ACES Drop #10

DROP #11

This was a three-platform drop configuration in a 20-16-12-foot platform arrangement with the 20-foot platform forward in the aircraft. The respective platform loads were 17600, 7670 and 6469 lb. The orifice in the hydraulic lines was opened to 0.081-in. diameter to reduce the resistance to positive rotation between the platforms. The center of gravity was forward of center at 43.4 percent of the assembled length. The load-transfer actuator was installed on the aft platform.

Performance was good. Due to the forward location of the center of gravity and the large sail area aft of the C.G., tip-off rotation was reversed by the aerodynamic loads at -40.4 degrees and the assembly was beginning to rotate in the positive or counterclockwise direction when the forward suspension slings became taut at 1.48 seconds after tip-off. The pull on the forward slings and the wind loads apparently produced offsetting moments about the C.G. and the assembly rotated very little until all of the suspension slings began to take on loads at about 5.68 seconds after tip-off. The parachutes had reached an advanced state of inflation at this time and produced large loads in both the forward and aft sets of compression links. A peak load of 124,000 lb was measured in a forward link. A corresponding load of 62,706 lb was measured in one of the truss members.

A mistake had been made in rigging the suspension slings, and an extra splice had been inserted in the aft end sling. This caused the 12-foot platform, in the fully suspended condition, to drop below the plane of the other two platforms. Some damage to the 12-foot truss assembly was caused at touchdown in this attitude. The damage, however, was moderate in extent and was readily repaired.

DROP DATA TEST NO. 11

DATE	4/3/80
TIME	10:20 AM
WIND VELOCITY	0
WIND DIRECTION	——
AIRCRAFT	C-141
A/C VELOCITY	150 KTS
A/C HEADING	206^{o}
A/C ALTITUDE	1500 FT AGL

PLATFORM CONFIGURATION

NO. OF PLATFORMS 3

ARRANGEMENT:	FWD	CENTER	AFT
LENGTH:	20 FT	16 FT	12 FT
WEIGHT:	17,600 LB	7,670 LB	6,469 LB

LENGTH OF PLATFORM ASSY.	51 FT
C.G. LOCATION FROM FWD END	22.14 FT
PERCENTAGE FROM FWD END	43%
EXTRACTED WEIGHT	34,009 LB
HYDRAULIC CYLINDER ORIFICE DIAMETER	0.081 IN.

RIGGING DATA

PARACHUTES:

EXTRACTION	28' RS
NO. OF CHUTES	2

RECOVERY G-11A

NO. OF CHUTES 8

EXTRACTION LINE LENGTH . . . . 120 FT

EXTRACTION RELEASE

TYPE . . . . 35 K

LOCATION FROM FWD EDGE OF PLATFORM ASSY . . . . 44.42 FT

PARACHUTE RELEASE . . . . 5,000 LB

SUSPENSION SLINGS

LOCATION:	FWD	CENTER FWD	CENTER AFT	AFT
LENGTH:	63 FT	123 FT	129 FT	68 FT

PERFORMANCE DATA

TIME:

GREEN LIGHT TO FIRST MOTION . . . . 7.39 SEC

FIRST MOTION TO EXTRACTION RELEASE . . . . 1.12 SEC

FIRST MOTION TO TIP OFF OF FWD PLATFORM . . . . 2.04 SEC

GREEN LIGHT TO IMPACT . . . . 52.47 SEC

EXTRACTION VELOCITY . . . . 47.32 FPS

ROTATION:

ANGLE AT TIP OFF:

PLATFORM REF PLANE . . . . -30.0°

FWD PLATFORM . . . . -7.3°

ANGLE BETWEEN PLATFORMS:

LOCATION:	FWD HINGE LINE	AFT HINGE LINE
MAX. POS. ANGLE	0°	(-) 24°
MAX. NEG. ANGLE	-30°	-28°

PLATFORM REF. PLANE MAX. ANGLE . . . . -40.4°

DESCENT:

TIME FROM TIPOFF TO FULL CANOPY . . . . -

TIME FROM TIPOFF TO ZERO FORWARD VELOCITY. . . . . -

TIME FROM TIPOFF TO STABLE RATE OF DESCENT . . . . -

ALTITUDE LOSS TO REACH VERT. VELOCITY OF 28.5 FPS .

VERTICAL VELOCITY AT IMPACT . . . .

HORIZONTAL VELOCITY AT IMPACT . . . . -

AVERAGE DESCENT RATE . . . . -

INSTRUMENTED DATA

COMPRESSION LINK LOADS:

FWD HINGE LINE LOCATION:

	PEAK	STEADY STATE
RIGHT SIDE	124,000 LB	43,000 LB
LEFT SIDE	103,000 LB	45,000 LB

AFT HINGE LINE LOCATION:

	PEAK	STEADY STATE
RIGHT SIDE:	70,000 LB	20,000 LB
LEFT SIDE:	51,000 LB	20,000 LB

TRUSS LOADS, PEAK

PLATFORM:	FWD	CENTER		AFT
LOCATION:	AFT	FWD	AFT	FWD
RIGHT SIDE:	-	64,498 LB	40,311 LB	-
LEFT SIDE:	-	62,706 LB	31,353 LB	-

RAIL LOADS, PEAK

PLATFORM	FWD	CENTER		AFT
LOCATION:	AFT	FWD	AFT	FWD
RIGHT SIDE:	-	61,360 LB	28,672 LB	-
LEFT SIDE:	-	44,840 LB	28,672 LB	-

SLING LOADS, PEAK

PLATFORM	FWD	CENTER		AFT
LOCATION:	AFT	FWD	AFT	FWD
RIGHT SIDE:	20,000 LB	-	-	-
LEFT SIDE:	7,000 LB	-	-	17,000 LB

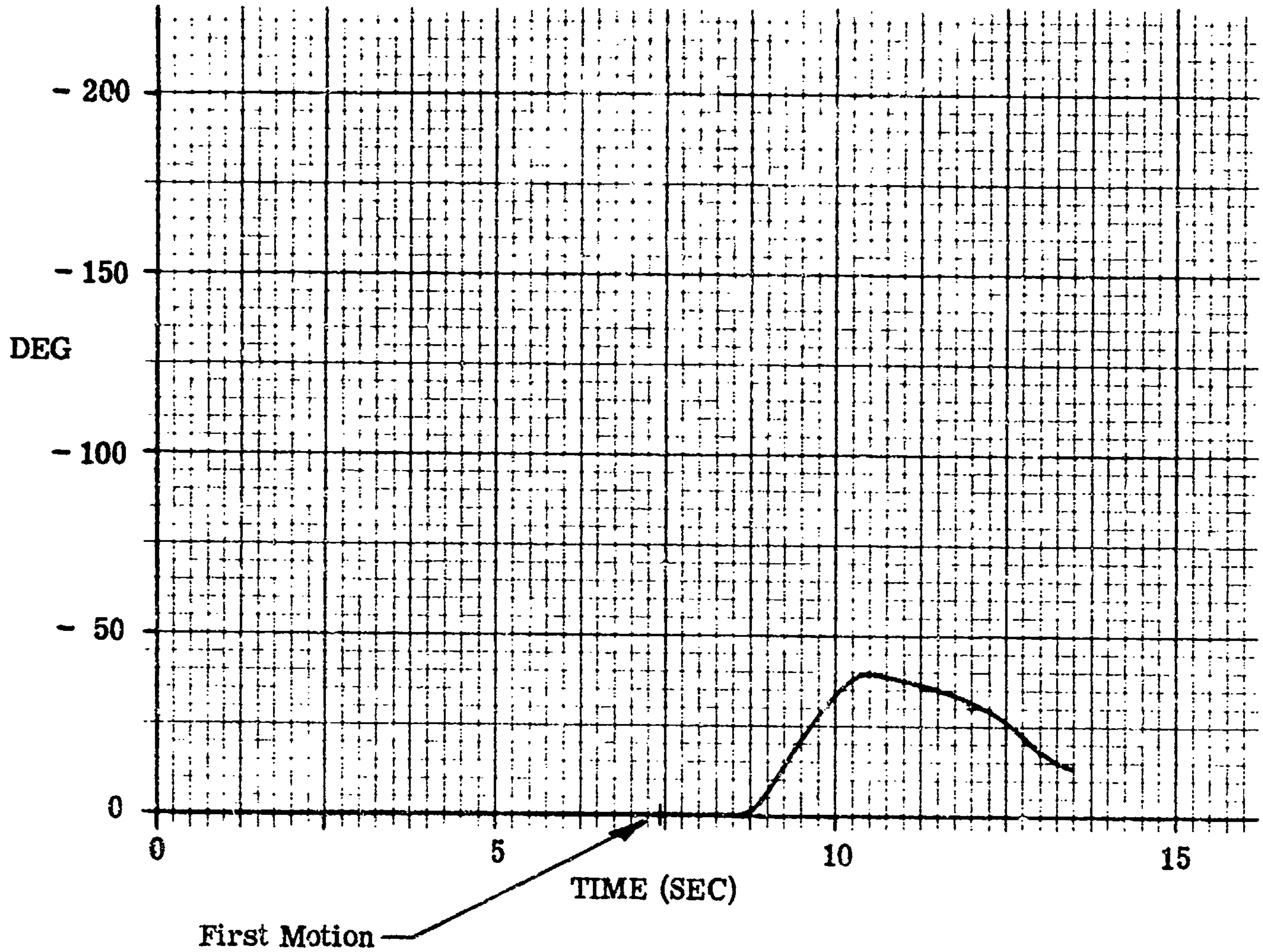


Figure 31. Platform Ref. Plane Angle vs. Time, ACES Drop #11

DROP #12

This was a three-platform assembly with a 20-foot platform forward, a 16-foot platform in the middle, and a 12-foot platform aft. The 16-foot platform carried a heavy load of 18,000 lb. The other two platforms were lightly loaded with 7600 lb on the 20-foot platform and 6469 lb on the 12-foot unit. The center of gravity was aft of center at 55.7 percent of the assembled length. The load-transfer actuator was on the aft platform. An 0.081-in. diameter orifice was used in the hydraulic control.

Performance during this test was good. Telemetry was lost just prior to initiation of the test and there was insufficient time to react and stop the test. No instrument data was obtained and very little photographic information was acquired because most of the operators had turned off their cameras. The assembly had a maximum rotation of about -138 degrees which was the only usable information obtained.

DROP DATA TEST NO. 12

DATE	4/16/80
TIME	1:30 PM
WIND VELOCITY	3 TO 5 MPH
WIND DIRECTION	240°
AIRCRAFT	C-141
A/C VELOCITY	150 KTS
A/C HEADING	206°
A/C ALTITUDE	1500 FT AGL

PLATFORM CONFIGURATION

NO. OF PLATFORMS 3

ARRANGEMENT:	FWD	CENTER	AFT
LENGTH:	20 FT	16 FT	12 FT
WEIGHT:	7,600 LB	18,100 LB	6,750 LB

LENGTH OF PLATFORM ASSY.	51 FT
C.G. LOCATION FROM FWD END	28.42 FT
PERCENTAGE FROM FWD END	56%
EXTRACTED WEIGHT	34,930 LB
HYDRAULIC CYLINDER ORIFICE DIAMETER	0.081 IN.

RIGGING DATA

PARACHUTES:

EXTRACTION	28' RS
NO. OF CHUTES	2

RECOVERY G-11A

NO. OF CHUTES 8

EXTRACTION LINE LENGTH . . . . 120 FT

EXTRACTION RELEASE

TYPE . . . . 35 K

LOCATION FROM FWD EDGE OF PLATFORM ASSY . . . . 44.42 FT

PARACHUTE RELEASE . . . . 5,000 LB

SUSPENSION SLINGS

		CENTER		
LOCATION:	FWD	FWD	AFT	AFT
LENGTH:	64.5 FT	120 FT	120 FT	63 FT

PERFORMANCE DATA

TIME:

GREEN LIGHT TO FIRST MOTION . . . . -

FIRST MOTION TO EXTRACTION RELEASE . . . . -

FIRST MOTION TO TIP OFF OF FWD PLATFORM . . . . -

GREEN LIGHT TO IMPACT . . . . -

EXTRACTION VELOCITY . . . . -

ROTATION:

ANGLE AT TIP OFF:

PLATFORM REF PLANE . . . . -

FWD PLATFORM . . . . -

ANGLE BETWEEN PLATFORMS:

LOCATION:	FWD HINGE LINE	AFT HINGE LINE
MAX. POS. ANGLE	-	-
MAX. NEG. ANGLE	-	-

PLATFORM REF. PLANE MAX. ANGLE . . . . -138.6^{o}

DESCENT:

TIME FROM TIPOFF TO FULL CANOPY . . . . -

TIME FROM TIPOFF TO ZERO FORWARD VELOCITY. . . . . -

TIME FROM TIPOFF TO STABLE RATE OF DESCENT . . . . -

ALTITUDE LOSS TO REACH VERT. VELOCITY OF 28.5 FPS . -

VERTICAL VELOCITY AT IMPACT . . . . -

HORIZONTAL VELOCITY AT IMPACT . . . . -

AVERAGE DESCENT RATE . . . . -

INSTRUMENTED DATA

COMPRESSION LINK LOADS:

FWD HINGE LINE LOCATION:

	PEAK	STEADY STATE
RIGHT SIDE	-	-
LEFT SIDE	-	-

AFT HINGE LINE LOCATION:

	PEAK	STEADY STATE
RIGHT SIDE:	-	-
LEFT SIDE:	-	-

TRUSS LOADS, PEAK

PLATFORM:	FWD	CENTER		AFT
LOCATION:	AFT	FWD	AFT	FWD
RIGHT SIDE:	-	-	-	-
LEFT SIDE:	-	-	-	-

RAIL LOADS, PEAK

PLATFORM	FWD	CENTER		AFT
LOCATION:	AFT	FWD	AFT	FWD
RIGHT SIDE:	-	-	-	-
LEFT SIDE:	-	-	-	-

SLING LOADS, PEAK

PLATFORM	FWD	CENTER		AFT
LOCATION:	AFT	FWD	AFT	FWD
RIGHT SIDE:	-	-	-	-
LEFT SIDE:	-	-	-	-

DROP #13

This was a three-platform assembly with a 16-foot platform forward, a 20-foot platform in the middle area and a 12-foot platform aft. The center platform carried a heavy load of 18,700 lb. The end platforms were lightly loaded with 6,900 lb forward and 6,550 lb aft. The center of gravity was near the geometric center at 52.6 percent of the assembled length. The load-transfer release mechanism was installed on the aft platform. An 0.089-in. diameter orifice was used in the hydraulic controls.

The equipment in this test performed in a letter-perfect manner. The aft suspension sling was the first to take up load at 1.80 seconds after tip-off. This pull reversed the direction of rotation at -117.3 degrees at about 2.50 seconds after tip-off. The forward suspension slings became taut at 3.92 seconds after tip-off. The peak compression link load was 111,000 lb in the aft set of links. The maximum steady state load in these links was 50,000 lb.

DROP DATA TEST NO. 13

DATE	4/23/80
TIME	10:37 AM
WIND VELOCITY	-
WIND DIRECTION	-
AIRCRAFT	C-141
A/C VELOCITY	150 KTS
A/C HEADING	206°
A/C ALTITUDE	1500 FT AGL

PLATFORM CONFIGURATION

NO. OF PLATFORMS 3

ARRANGEMENT:	FWD	CENTER	AFT
LENGTH:	16 FT	20 FT	12 FT
WEIGHT:	6,900 LB	18,700 LB	6,550 LB

LENGTH OF PLATFORM ASSY.	51.08 FT
C.G. LOCATION FROM FWD END	26.84 FT
PERCENTAGE FROM FWD END	53%
EXTRACTED WEIGHT	34,630 LB
HYDRAULIC CYLINDER ORIFICE DIAMETER	0.089 IN.

RIGGING DATA

PARACHUTES:

EXTRACTION	28' RS
NO. OF CHUTES	2

RECOVERY G-11A

NO. OF CHUTES 8

EXTRACTION LINE LENGTH . . . . 120 FT

EXTRACTION RELEASE

TYPE . . . . 35 K

LOCATION FROM FWD EDGE OF PLATFORM ASSY . . . . 44.5 FT

PARACHUTE RELEASE . . . . 5,000 LB

SUSPENSION SLINGS

LOCATION:	FWD	CENTER FWD	CENTER AFT	AFT
LENGTH:	64.5 FT	120 FT	120 FT	64 FT

PERFORMANCE DATA

TIME:

GREEN LIGHT TO FIRST MOTION . . . . 4.09 SEC

FIRST MOTION TO EXTRACTION RELEASE . . . . 1.15 SEC

FIRST MOTION TO TIP OFF OF FWD PLATFORM . . . . 2.21 SEC

GREEN LIGHT TO IMPACT . . . . 51.55 SEC

EXTRACTION VELOCITY . . . . 47.82 FPS

ROTATION:

ANGLE AT TIP OFF:

PLATFORM REF PLANE . . . . -19.7°

FWD PLATFORM . . . . -6.5°

ANGLE BETWEEN PLATFORMS:

LOCATION:	FWD HINGE LINE		AFT HINGE LINE
MAX. POS. ANGLE	5°	. . . . .	3°
MAX. NEG. ANGLE	-10°	. . . . .	-24°

PLATFORM REF. PLANE MAX. ANGLE . . . . -117.3°

DESCENT:

TIME FROM TIPOFF TO FULL CANOPY . . . . -

TIME FROM TIPOFF TO ZERO FORWARD VELOCITY. . . . . -

TIME FROM TIPOFF TO STABLE RATE OF DESCENT . . . . -

ALTITUDE LOSS TO REACH VERT. VELOCITY OF 28.5 FPS . -

VERTICAL VELOCITY AT IMPACT . . . . -

HORIZONTAL VELOCITY AT IMPACT . . . . -

AVERAGE DESCENT RATE . . . . -

INSTRUMENTED DATA

COMPRESSION LINK LOADS:

FWD HINGE LINE LOCATION:

	PEAK	STEADY STATE
RIGHT SIDE	85,000 LB	30,000 LB
LEFT SIDE	90,000 LB	27,000 LB

AFT HINGE LINE LOCATION:

	PEAK	STEADY STATE
RIGHT SIDE:	100,000 LB	53,000 LB
LEFT SIDE:	111,000 LB	50,000 LB

TRUSS LOADS, PEAK

PLATFORM:	FWD	CENTER		AFT
LOCATION:	AFT	FWD	AFT	FWD
RIGHT SIDE:	-	51,956 LB	-	-
LEFT SIDE:	-	49,259 LB	67,185 LB	-

RAIL LOADS, PEAK

PLATFORM	FWD	CENTER		AFT
LOCATION:	AFT	FWD	AFT	FWD
RIGHT SIDE:	-	-	34,406 LB	-
LEFT SIDE:	-	33,040 LB	-	-

SLING LOADS, PEAK

PLATFORM	FWD	CENTER		AFT
LOCATION:	AFT	FWD	AFT	FWD
RIGHT SIDE:	3,500 LB	6,000 LB	16,000 LBS.	11,000 LB
LEFT SIDE:	3,000 LB	-	-	-

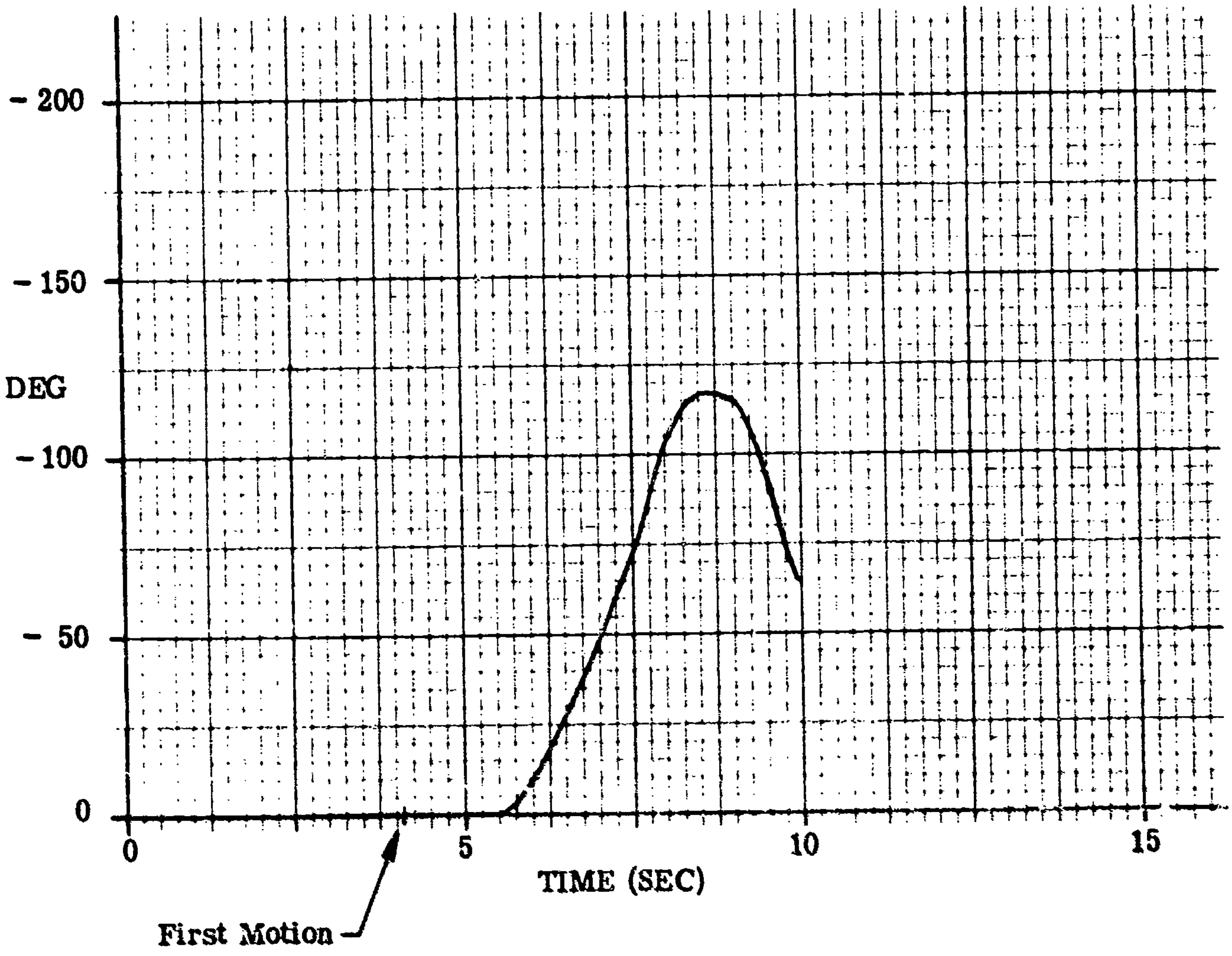
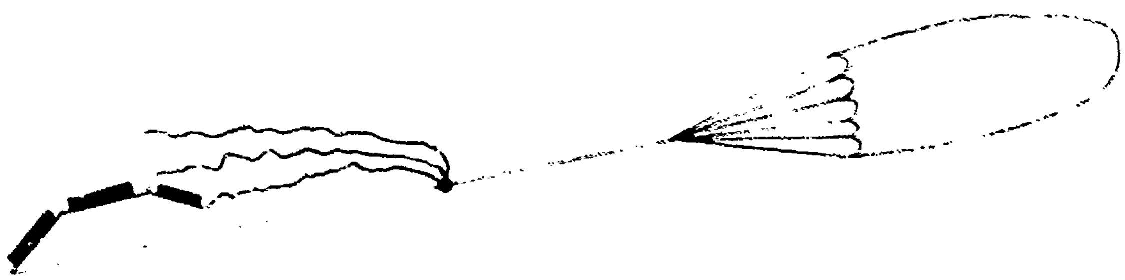


Figure 32. Platform Ref. Plane Angle vs. Time, ACES Drop #13

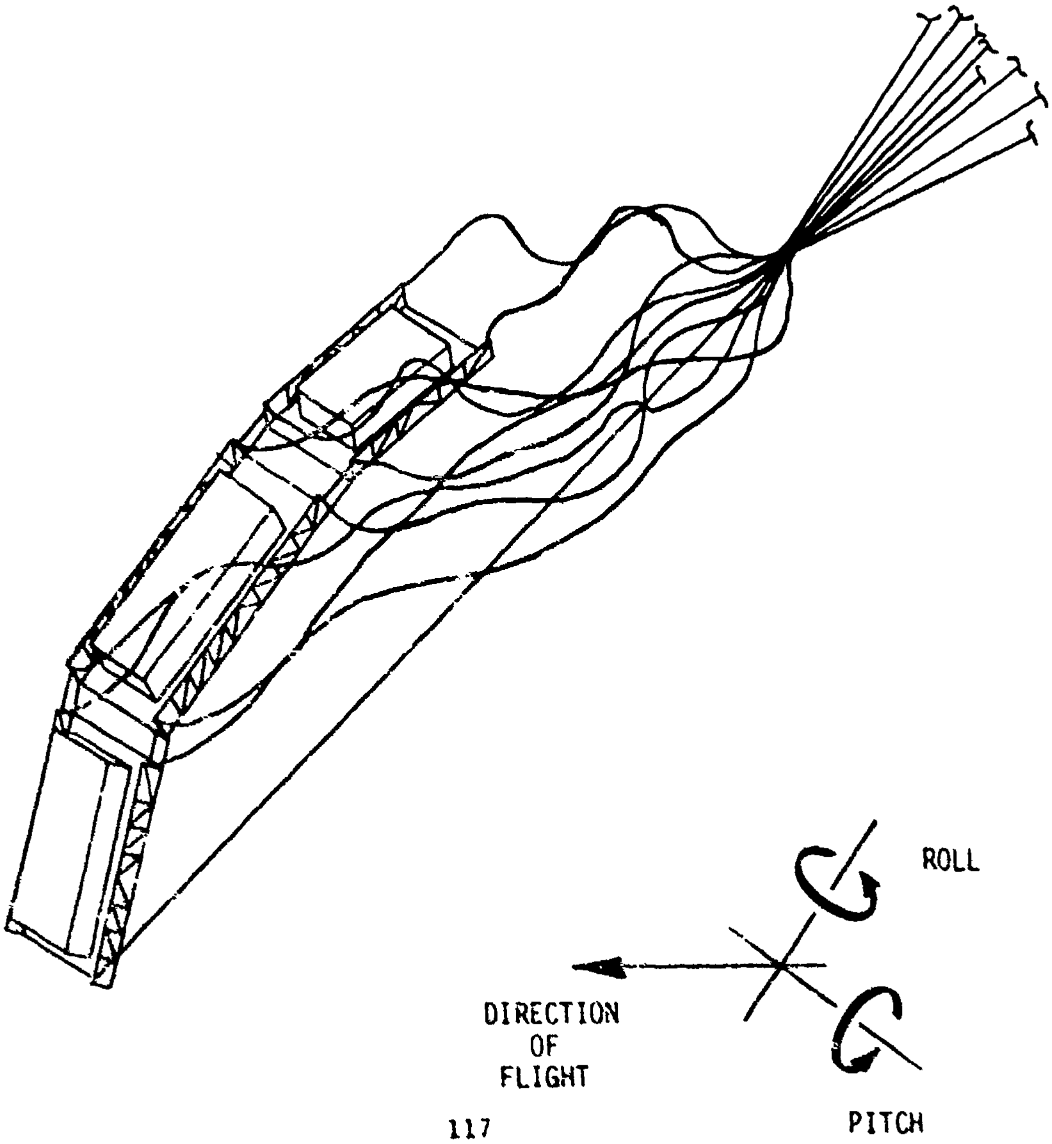
DROP #14

This was a three-platform assembly with a 16-foot platform forward, a 20-foot platform in the center, and a 12-foot platform aft. The forward 16-foot platform was heavily loaded at 17,350 lb. The other two platforms carried light loads with 8,091 lb on the 20-foot platform and 6,550 lb on the 12-foot unit. The center of gravity was well forward at 41.5% of the assembled length. The force-transfer release mechanism was on the aft platform. The orifice opening in the hydraulic controls was 0.089 inch diameter.

The equipment failed to function properly in this test. Structural failures occurred shortly after tip-off and the assembly broke apart and was lost. Extraction was accomplished in a satisfactory manner, but about 10-seconds after tip-off negative rotation was arrested at a reference plane angle of -33 degrees, and rotation in the positive direction began. This was caused by the large sail area aft of the center of gravity. The wind acting on the bottom surface of the platforms generated forces large enough to arrest the rotation caused by tip-off and generate a reverse rotation. At 1.53 seconds after tip-off the forward suspension slings became taut. The assembly was in the following situation at this time.



The pull of the slings acting below the center of gravity accelerated positive rotation and the assembly rotated to a positive angle of about 55 degrees at 6.0 seconds after tip-off. At this point the parachutes were in an advanced state of inflation and produced considerable pull. The load in the forward suspension sling reached about 24,000 lb causing the shear of a bolt that attached the load measuring link to the platform assembly. This failure started a sequence of failures and the assembly came apart in mid air. The assembly was in the following attitude when the sling failure occurred.



DROP DATA TEST NO. 14

DATE	4/30/80
TIME	10:19 AM
WIND VELOCITY	0
WIND DIRECTION	——
AIRCRAFT	C-141
A/C VELOCITY	1500 KTS
A/C HEADING	206°
A/C ALTITUDE	1500 FT AGL

PLATFORM CONFIGURATION

NO. OF PLATFORMS 3

ARRANGEMENT:	FWD	CENTER	AFT
LENGTH:	16 FT	20 FT	12 FT
WEIGHT:	17,350 LB	8,091 LB	6,550 LB

LENGTH OF PLATFORM ASSY.	51.08 FT
C.G. LOCATION FROM FWD END	21.21 FT
PERCENTAGE FROM FWD END	42%
EXTRACTED WEIGHT	34,471 LB
HYDRAULIC CYLINDER ORIFICE DIAMETER	0.089 IN.

RIGGING DATA

PARACHUTES:

EXTRACTION	28' RS
NO. OF CHUTES	2

RECOVERY G-11A

NO. OF CHUTES 8

EXTRACTION LINE LENGTH . . . . 120 FT

EXTRACTION RELEASE

TYPE . . . . 35 K

LOCATION FROM FWD EDGE OF PLATFORM ASSY . . . . 44.5 FT

PARACHUTE RELEASE . . . . 5,000 LB

SUSPENSION SLINGS

LOCATION:	FWD	CENTER FWD	CENTER AFT	AFT
LENGTH:	63 FT	123 FT	129 FT	68 FT

PERFORMANCE DATA

TIME:

GREEN LIGHT TO FIRST MOTION . . . . 5.54 SEC

FIRST MOTION TO EXTRACTION RELEASE . . . . 1.19 SEC

FIRST MOTION TO TIP OFF OF FWD PLATFORM . . . . 2.12 SEC

GREEN LIGHT TO IMPACT . . . . 15.85 SEC

EXTRACTION VELOCITY . . . . 46.09 FPS

ROTATION:

ANGLE AT TIP OFF:

PLATFORM REF PLANE . . . . -15.6^{0}

FWD PLATFORM . . . . -2.3^{0}

ANGLE BETWEEN PLATFORMS:

LOCATION:	FWD HINGE LINE		AFT HINGE LINE
MAX. POS. ANGLE	-	. . . . .	-
MAX. NEG. ANGLE	-30^{0}	. . . . .	-30^{0}

PLATFORM REF. PLANE MAX. ANGLE . . . . -33.3^{0}

DESCENT:

TIME FROM TIPOFF TO FULL CANOPY	-
TIME FROM TIPOFF TO ZERO FORWARD VELOCITY.	-
TIME FROM TIPOFF TO STABLE RATE OF DESCENT	-
ALTITUDE LOSS TO REACH VERT. VELOCITY OF 28.5 FPS .	-
VERTICAL VELOCITY AT IMPACT	-
HORIZONTAL VELOCITY AT IMPACT	-
AVERAGE DESCENT RATE	-

INSTRUMENTED DATA

COMPRESSION LINK LOADS:

FWD HINGE LINE LOCATION:

	PEAK	STEADY STATE
RIGHT SIDE	38,000 LB	-
LEFT SIDE	37,000 LB	-

AFT HINGE LINE LOCATION:

	PEAK	STEADY STATE
RIGHT SIDE:	25,000 LB	-
LEFT SIDE:	25,000 LB	-

TRUSS LOADS, PEAK

PLATFORM:	FWD	CENTER		AFT
LOCATION:	AFT	FWD	AFT	FWD
RIGHT SIDE:	-	20,603 LB	20,603 LB	-
LEFT SIDE:	-	22,395 LB	15,229 LB	-

RAIL LOADS, PEAK

PLATFORM	FWD	CENTER		AFT
LOCATION:	AFT	FWD	AFT	FWD
RIGHT SIDE:	-	21,240 LB	9,318 LB	-
LEFT SIDE:	-	18,880 LB	12,902 LB	-

SLING LOADS, PEAK

PLATFORM	FWD	CENTER		AFT
LOCATION:	AFT	FWD	AFT	FWD
RIGHT SIDE:	8,000 LB	9,000 LB	17,399 LB	-
LEFT SIDE:	24,000 LB	-	-	34,000 LB

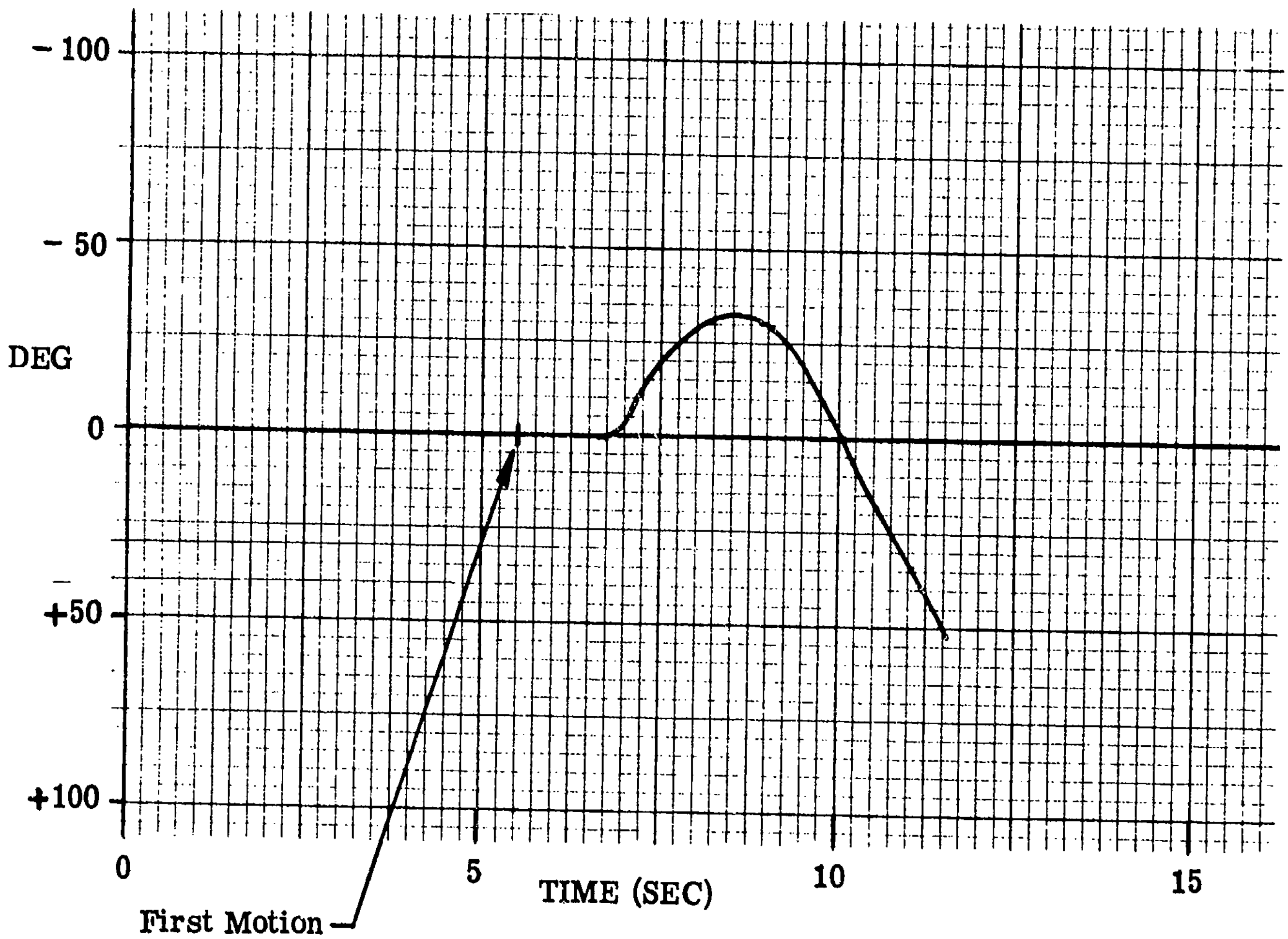


Figure 33. Platform Ref. Plane Angle vs. Time, ACES Drop #14

A large part of the data used in the preceding discussions is presented in summary form in Table 4.

Table 4. Summary of Test Data

	2 PLATFORMS							3 PLATFORMS						
DROP NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
FWD PLATFORM LG	12 FT	12 FT	12 FT	12 FT	16 FT	20 FT	20 FT	12 FT	12 FT	20 FT	20 FT	20 FT	16 FT	16 FT
WT	5,200	8,770	18,000	5,200	6,500	7,500	7,500	4,800	11,870	7,600	17,600	7,600	6,900	17,350
CG LOCATION FROM FWD EDGE OF PLATFORM	81"	83"	72"	81"	96"	125"	120"	83"	74"	126"	123"	115"	102"	108"
CENTER PLATFORM LG								12 FT	12 FT	16 FT	16 FT	16 FT	20 FT	20 FT
WT								5,600	5,500	6,900	7,670	18,100	18,700	8,091
CG LOCATION FROM FWD EDGE OF PLATFORM								78"	78"	102.5"	102"	102"	115"	124.5"
AFT PLATFORM LG	12 FT	12 FT	12 FT	12 FT	12 FT	12 FT	16 FT	12 FT	12 FT	12 FT	12 FT	12 FT	12 FT	12 FT
WT	5,550	5,200	5,200	12,000	5,575	5,575	5,600	5,400	5,400	6,429	6,469	6,750	6,550	6,550
CG LOCATION FROM FWD EDGE OF PLATFORM	83.5"	81"	81"	72"	72"	72"	96"	81"	81"	73"	73"	74"	74"	74"
TOTAL SUSPENDED WT	10,750	13,970	23,200	17,200	12,075	13,075	13,100	15,800	22,870	20,929	31,739	32,450	32,150	31,991
PLATFORM ASSY LG	25'4"	25'4"	25'4"	25'4"	29'5"	33'6"	37'7"	38'8"	38'8"	51'	51'	51'	51'1"	51'1"
C.G. LOCATION FROM FWD END	13.74'	11.82'	9.16'	15.53'	15.12'	17.70'	18.37'	20.55'	15.95'	27.59'	22.14'	28.42'	26.84'	21.21'
PERCENT OF LENGTH	54.2%	46.7%	36.2%	61.3%	51.4%	52.8%	48.8%	53.1%	41.2%	54.1%	43.4%	55.7%	52.6%	41.3%
35K RELEASE ACTUATOR ARM (ARMED) LOCATION FROM: AFT EDGE AFT PLATFORM	19'8"	6'7"	6'7"	6'7"	6'7"	6'7"	8'9"	20'1"	6'7"	6'7"	6'7"	6'7"	6'7"	6'7"
FWD EDGE FWD PLATFORM	5'8"	18'9"	18'9"	18'9"	22'10"	26'11"	28'10"	18'7"	32'1"	44'5"	44'5"	44'5"	44'6"	44'6"
EXIT VELOCITY FT/SEC AT EXTRACTION RELEASE	38.7	40	40	30	32.5	50	35.8	47.7	30.8	41.1	47.3	-	47.8	46.1
TIME FROM FIRST MOTION TO EXTRACTION RELEASE (SEC)	1.49	.98	1.12	1.10	1.14	.80	.88	1.35	1.04	1.29	1.12	-	1.15	1.19
TIME FROM EXTRACTION RELEASE TO MAIN CHUTES LEAVING PLATFORM	.14	.19	.23	.22	.20	.16	.25	.19	.27	.23	.18	-	.21	.25
TIME FROM FIRST MOTION TO TIP-OFF OF FWD PLATFORM	1.59	1.44	1.67	1.56	1.81	1.41	1.56	1.74	1.97	2.32	2.04	-	2.21	2.12
ANGLE OF FWD PLATFORM	6.4°	1.4°	9.8°	4.8°	3.1°	4.6°	2.4°	2.1°	12.1°	4.5°	7.3°	-	6.5°	2.3°
PLATFORM REF PLANE ANGLE	6.8°	5.4°	17.3°	16.1°	14.2°	14.1°	14.2°	11.2°	27.5°	20.4°	20.0°	-	19.7°	15.6°
PLATFORM REF PLANE ANGLE, EVERY .50 SEC STARTING FROM TIP-OFF (MAX ROTATION boxed; ALL ANGLES NEGATIVE EXCEPT AS NOTED.) .5	20.1°	19.2°	33.0°	66.0°	31.0°	34.0°	34.3°	30.5°	41.0°	38.1°	33.3°	NO DATA	39.9°	29.9°
1.0	47.8°	25.0°	40.0°	123.5°	66.5°	52.0°	44.8°	52.1°	45.4°	46.0°	40.4°		63.4°	33.3°
1.5	105.0°	46.7°	36.5°	187.5°	97.3°	78.0°	60.0°	77.2°	47.3°	79.0°	39.0°		92.6°	28.8°
2.0	153.4°	88.0°	43.0°	234.5°	113.5°	111.0°	81.5°	107.0°	55.0°	105.3°	35.8°		114.8°	18.0°
2.5	183.6°	84.5°	51.0°	226.0°	114.5°	126.8°	102.5°	132.5°	62.0°	126.0°	31.2°		117.3°	1.2°
3.0	208.8°	49.0°	58.5°	176.0°	98.0°	133.0°	102.5°	156.7°	70.0°	139.0°	26.0°		104.0°	+17.8°
3.5	210.7°		55.0°	129.0°	73.3°	132.3°	91.5°	179.0°	69.5°	148.2°	20.1°		76.2°	+33.7°
4.0	175.8°		35.0°	87.0°	55.0°	123.2°	63.4°	193.5°	55.0°	154.7°				+52.0°
4.5	113.6°		28.0°			81.5°	49.0°	179.0°	44.8°	158.8°				+55.1°
5.0	54.6°		30.0°			43.5°		147.0°		153.5°				
5.5								105.0°		136.0°				
SLING SNATCH, TIME FROM TIP-OFF. FWD SLING	4.68	1.67	1.78	NO DATA	3.61	4.94	1.67	6.22	1.59	1.19	1.48	NO DATA	3.92	1.53
AFT SLING	2.04	2.22	NO SNATCH	NO DATA	2.03	2.14	2.37	2.46	3.17	2.02	5.68	NO DATA	1.80	NO SNATCH
ROTATION BETWEEN PLATFORMS FWD AFT PLATFORM (-)			-14.2°	-24°	-25°	-25.7°	-26.8°							
" " " (+)			0°	0°	0°	0°	0°							
FWD CENTER PLATFORM (-)								-8°	-10°	-27°	-30°	NO DATA	-10°	-30°
" " " (+)								+3°	LOST LOAD		0°		5°	LOST LOAD
CENTER AFT PLATFORM (-)								-24°	-29°	-25.5	-28°		-24°	-30°
" " " (+)								0°			-24°		3°	
HYD CYL ORIFICE DIA	070	.070	.070	.070	.070	.070	.070	.070	.070	.070	.081	.081	.089	.089

C. Discussion of Test Results

The concept of using hydraulic cylinders to control the attitude of the individual platforms relative to each other was shown to be sound. This mechanism provides the basic equipment necessary for the practical implementation of the ACES concept. Rotation in the negative or tip-off direction is unrestricted up to -30 degrees. All of this negative travel was used in a number of tests and the pistons in the hydraulic cylinders bottomed out. The loads resulting from this bottoming action, however, were small, and there appears to be no great need to increase the amount of unrestricted travel. Rotation in the positive direction is constrained by forcing the oil to flow through an orifice. Rotation to a positive angle of +30 degrees was provided in the equipment, but the constraints were such that rotation in this direction seldom progressed beyond zero degrees. A maximum positive angle of +5 degrees was measured in test No. 13. Greater freedom to rotate in the positive direction may be beneficial, and a plan was in effect to investigate this factor by gradually increasing the orifice size in the cylinders. On tests 13 and 14 the orifice diameter had been increased to 0.089 inches. The results of test 13 produced a small positive angle and the probability is that the orifice size could be larger and still exercise the needed control. The important consideration is that the tests show that effective control can be provided that will limit positive rotation to 30 degrees or less, and this is a practicalvalue for use in an ACES design.

A highly significant finding of the test program was the effect the location of the center of gravity of the composite load has on the performance of the system. In those configurations with the location of the center of gravity within five percentage points of the geometric center, no significant effect of the wind loads on system performance is observed. On tests 3, 4, 9, 11 and 14 the center of gravity was located more than five percentage points from the geometric center and a decided effect can be observed. Each of these tests is discussed individually.

In test No. 3 the center of gravity was forward of the geometric center at 36.2 percent of the assembled length. The wind acting on the sail area aft of the C.G. generated sufficient moment about the center of gravity to noticeably retard tip-off rotation and restrict the maximum angle of the reference plane to 58.5 degrees. In this test the wind effects, although considerable, in no way endangered the equipment, and in fact, may have had a beneficial effect on performance. The beneficial effects of the wind on this configuration can be observed by comparing the performance of this test with tests No. 1 and No. 2. In test No. 2 a similar configuration was dropped, but the difference in platform weights was not as great and the center of gravity was at 46.7 percent of the assembled length. Performance of this configuration was very good. In test No. 1 the center of gravity was at 54.2 percent of the assembled length, and the system was endangered when the reference plane angle reached a negative value of -210.7 degrees. The wind effects, if any, may have increased rotation and contributed to the excessively large rotation.

In test No. 4 the center of gravity was aft of the geometric center at 61.3 percent of the assembled length. Gravity effects at tip-off plus the wind forces forward of the C.G. caused this assembly to rotate to -234.5 degrees. This was a highly dangerous situation, and a possible disaster was averted by the fact that the aft suspension slings settled inside the truss assembly rather than slide to the underneath side of the platform where pull on the slings would have added to the negative rotation rather than reverse it. This experience indicates that the use of some means to encourage the slings to settle within the truss limits when large rotations occur would be beneficial.

In test No. 9 the center of gravity was at 41.2 percent of the assembled length. Negative rotation was limited to -70 degrees. Comparing this with test No. 8 where negative rotation was -193.5 degrees indicates that the wind had a beneficial effect on performance.

In test No. 11 the center of gravity was at 43.4 percent of the assembled length. The sail area aft of the C.C. was substantial in this configuration due to the use of 20 and 16-foot platforms in the assembly. Negative rotation was completely overcome by the wind loads and rotation was limited to -40.4 degrees which endangered the system.

In test No. 14 the center of gravity was at 41.5 percent of the assembled length. Also the use of the 20 and 16-foot platforms increased the amount of sail area and the effects of the wind limited negative rotation to -33.3 degrees which led to an accident and loss of the equipment.

These observations indicate that the wind effects can be both beneficial and detrimental. In the two-platform configurations it appears that a center of gravity forward of the geometric center allows the wind loads to limit negative rotation and in this manner is beneficial to performance. In the three-platform configurations the sail areas become quite large, and the center of gravity must be located within narrow limits of the geometric center or serious consequences may result. This can be controlled by placing the heaviest load on the center platform. Additional testing is needed to examine the extent of the limits on the center of gravity location.

Long suspension slings were employed in the ACES concept so that the attitude of the platform assembly at touchdown would be fairly uniform regardless of where the center of gravity was located. This concept appeared to be sound and should be retained. In early tests the long suspension slings caused rigging problems in arranging the slings on the load. Line bags were improvised that improved this situation a great deal. Plans to continue the use of line bags and improve on their design is desirable.

Except for the structural problem on test No. 10, which was subsequently corrected, no structural problems with the equipment were experienced during the airborne phases of the airdrop tests. Several structural failures, all of a repairable nature, were experienced in landing the assemblies. On most drops the assembly at touchdown has some horizontal component of velocity due to the wind, and this may cause the assembly to plow into the slope of a hill or even dig into level ground if the assembly is not completely level. This occurred in several instances resulting in sheared bolts and in some instances deformed truss members. Also the ACES assemblies are quite long and if the ground is not level the assembly may bridge over a ground depression causing excessive loads in the structure. This damage experience in no way jeopardized the payloads, but it did require maintenance attention to repair the platform structure. In most instances this amounted to replacement of sheared bolts. In a few instances it required straightening of some truss members.

The location of the load transfer release mechanism was an experimental subject during the tests. It had been planned to install this unit on the forward platform in the two-platform configurations and on the middle unit in the three-platform assemblies. Following the first test, the advantage of deploying the recovery parachutes as quickly as possible was apparent. This assembly rotated to a dangerous angle before the parachutes began to exercise control. It was reasoned that locating the release on the aft platform would deploy the recovery parachutes a few milliseconds earlier, and in this airdrop operation a fraction of a second is often significant. The negative factor in an aft platform installation is a possible safety consideration. The extraction force is released earlier and the possibility of a load hang-up on the ramp must be considered. Following study of the first test performance and detail analysis, the possibility of a hang-up appeared remote and the change was made. This aft platform location was used on all tests except No. 8, the first of the three-platform configuration tests. The lowest extraction velocity measured during the test series was 30 feet per second on test No. 4. Location of the release on the aft platform appears to be beneficial to ACES system performance and should be adopted.

The monitoring of loads in the system was an important part of the test plan and a substantial quantity of good data was acquired during the test program. The compression link loading is quite significant and fortunately these components are easy to remove and calibrate. A procedure was followed for calibrating the gages on these links before each test, therefore, the reliability of the compression link data should be quite good. The load data shows a distinct dichotomy consisting of peak loads and steady state loads. The peak loads occur during the early phases of the drop when the recovery parachutes are deploying and beginning to assume control of the platforms assembly. The suspension slings secured to the ends of the assembly usually alternate in becoming taut and influencing the attitude of the platform assembly. When these slings become loaded, they develop loads that la t a few milliseconds. They develop loads in the compression links and the truss structure that peak in the same manner. The value of these peak loads is considerably greater than the steady state loads. The largest peak load measured in a compression link was 124,000 lb in test No. 10. Steady state loads arising from wind effects and the steady pull of suspension lines are also well-defined in the data. The largest steady state load in a compression link was 53,000 lb measured in test No. 13.

The standard airdrop hardware and components used throughout the ACES system functioned well throughout the test program except for the M-2 parachute release. It functioned in mid air on test No. 9 causing a disastrous loss of equipment. Individual 5,000-lb parachute releases were used during the remainder of the tests. The probable cause of the M-2 malfunction was investigated at NLABS. The release must be installed so that the flat side or plane of the release is perpendicular to the longitudinal or long axis of the platforms assembly. It was concluded that an incorrect orientation of the unit was the probable cause of the premature release.

VIII. CONCLUSIONS

The following conclusions are drawn from the findings of this test program.

- The performance of the equipment during the tests indicates that concepts are sound and there is a very good probability they can be developed to provide an ACES system that will satisfy system objectives.
- The concept of controlling the attitude of the individual platforms relative to each other with hydraulic cylinders was shown to be a sound approach. This provides the basic element in the equipment required for practical implementation of the ACES Concept.
- Wind loads have a significant effect on system performance. Considerable insight was acquired during the test program on how platforms assemblies can be configured to use the beneficial as well as avoid the detrimental effects of the wind loads.
- Early deployment of the recovery parachutes aids rapid acquisition of control of the platform assemblies. Location of the load transfer release mechanism on the aft platform helps significantly in achieving this early deployment.
- The use of long suspension slings is necessary for control of the attitude of the assembly at touchdown. The innovative use of line bags for rigging these long suspension slings was highly successful. Their continued use should be factored into future ACES planning.
- Measured system loads dichotomize into peak loads and steady state loads. If the means could be devised to reduce the peak loads to a level approaching the level of the steady state loads, system structural requirements would be significantly reduced.

- The ACES technique of linking the platforms required some minor alterations in procedures for installation of loads in the aircraft. Problems arising from these changes were readily resolved, therefore, compatibility of the ACES concept with the aircraft appears to be assured.
- No problems in rigging the test tubs to the modified ACES platforms were encountered. Provisions for rigging appear to be adequate, and current rigging procedures will be applicable in the ACES system.

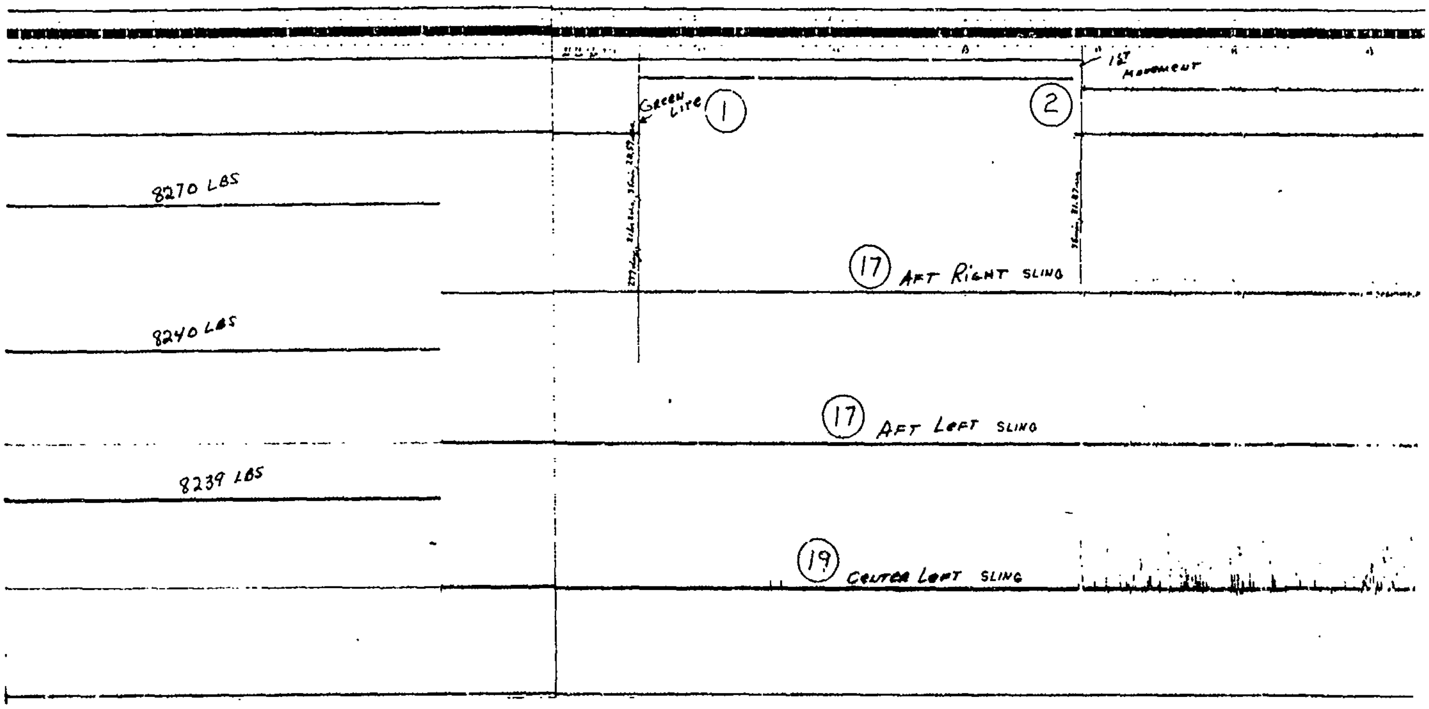
IX. RECOMMENDATIONS

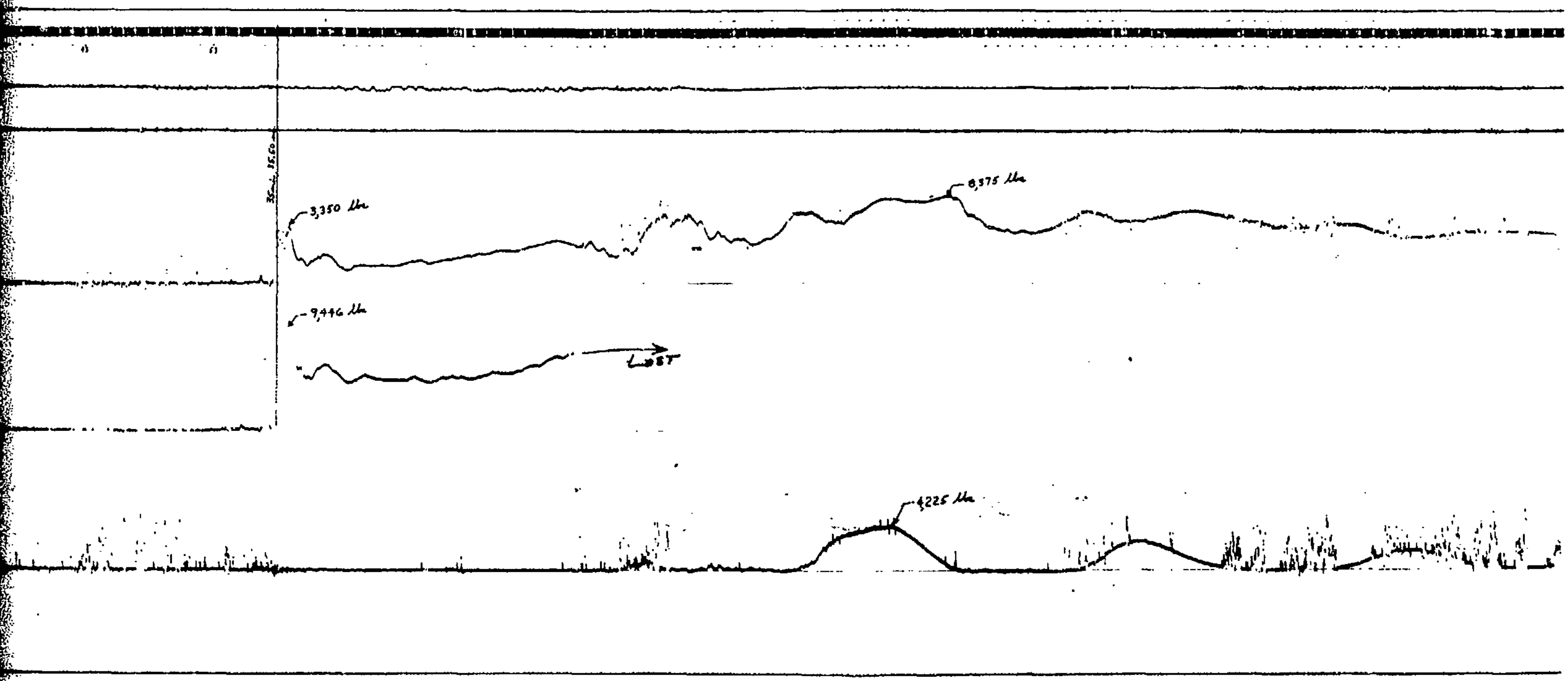
The following recommendations are developed based upon the experience of this test program.

- Performance of the equipment during the test program demonstrated that the concepts are sound and have an excellent potential for full satisfaction of ACES objectives. It is recommended, therefore, that development of the system be continued, and the information acquired during these tests be used to modify designs and expand the types of equipment to advance the ACES Concept toward certification for application by the user.

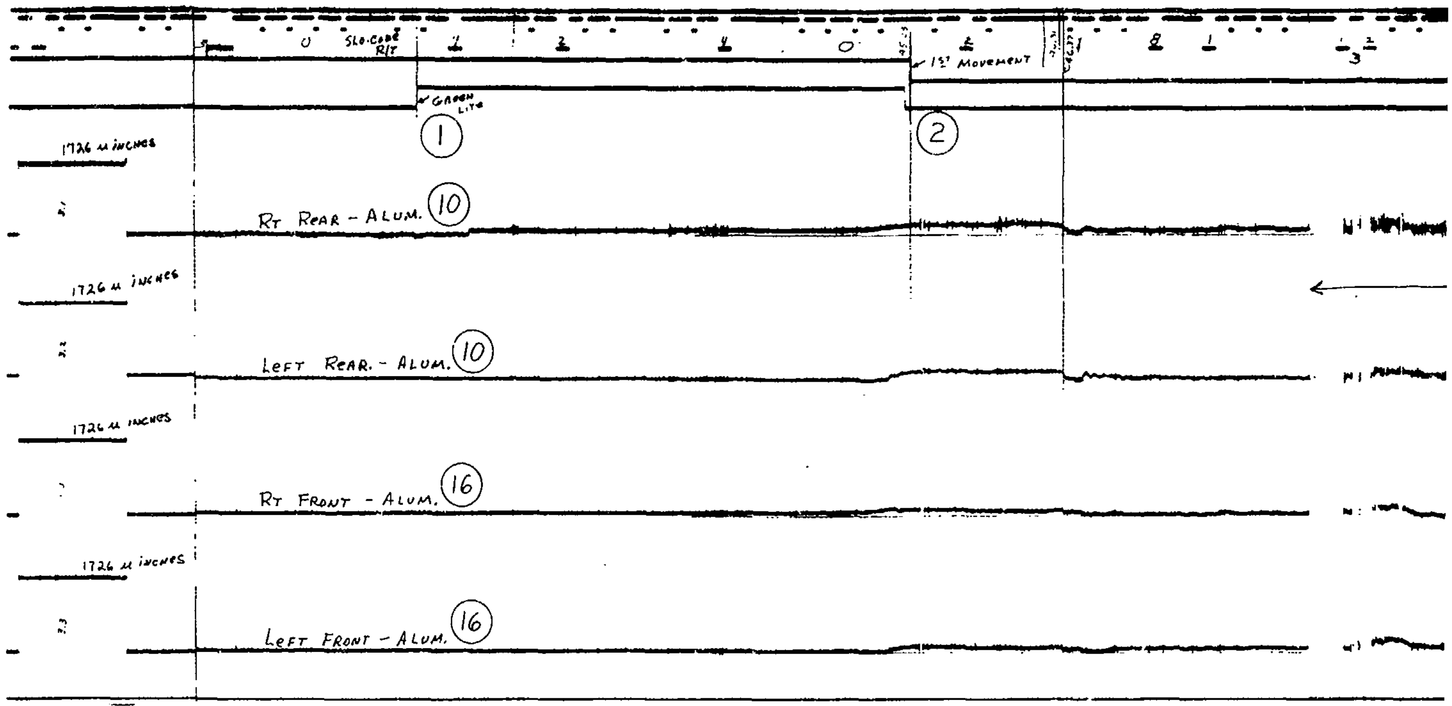
APPENDIX

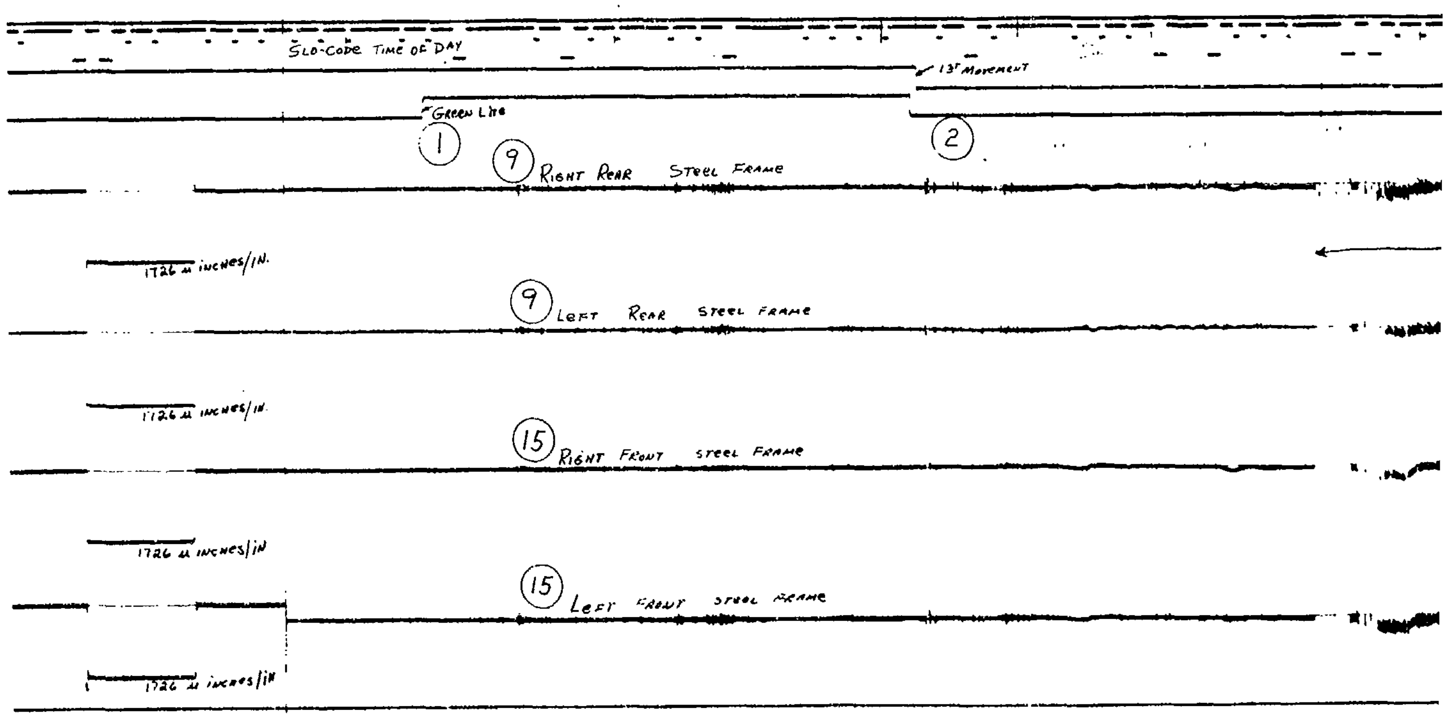
Printouts of Instrumented Data
Obtained During Testing

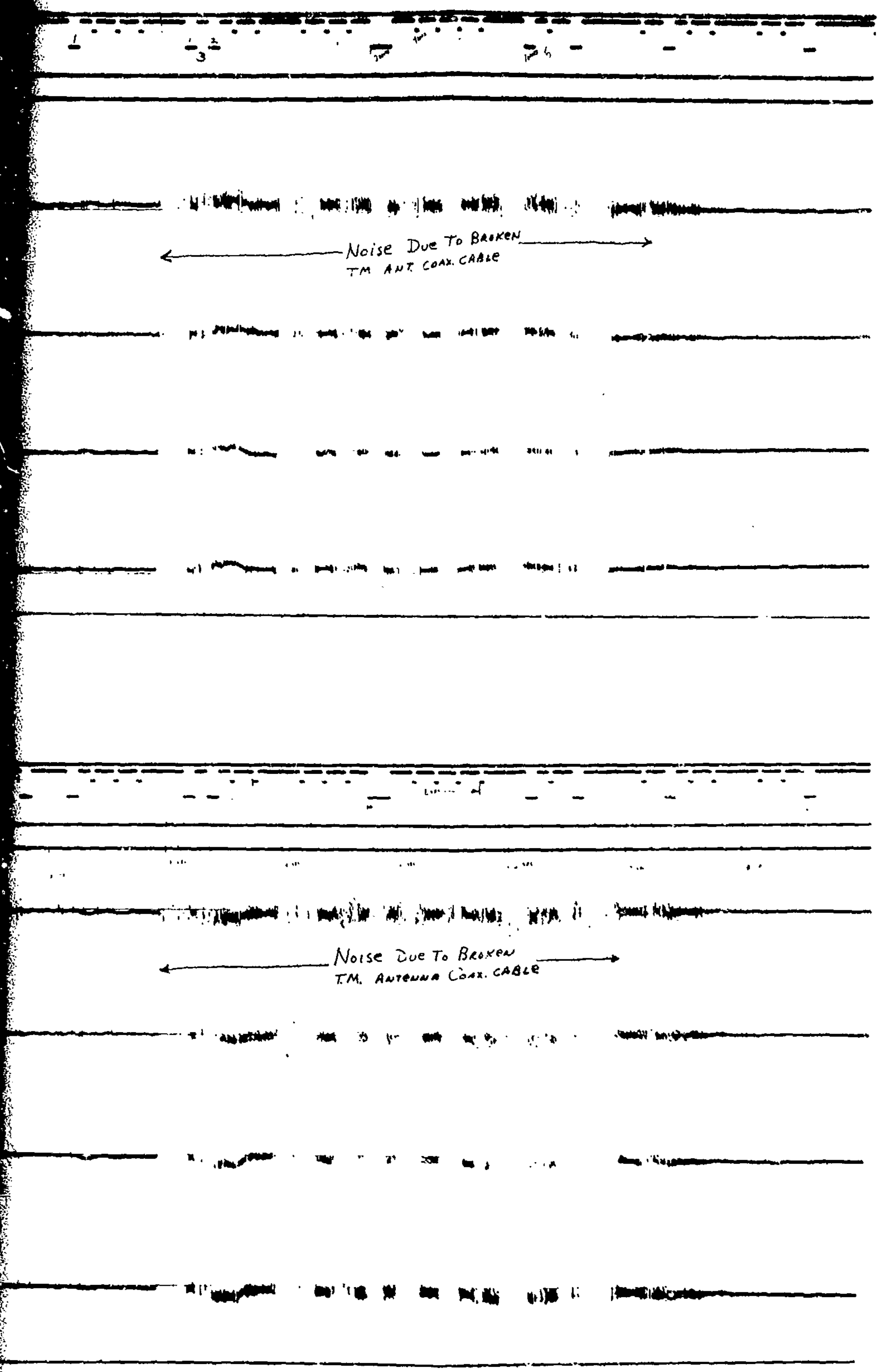

8270 LBS
8240 LBS
8239 LBS
GREEN LITE
1
2
1st MOVEMENT
17 AFT RIGHT SLING
17 AFT LEFT SLING
19 CENTER LEFT SLING



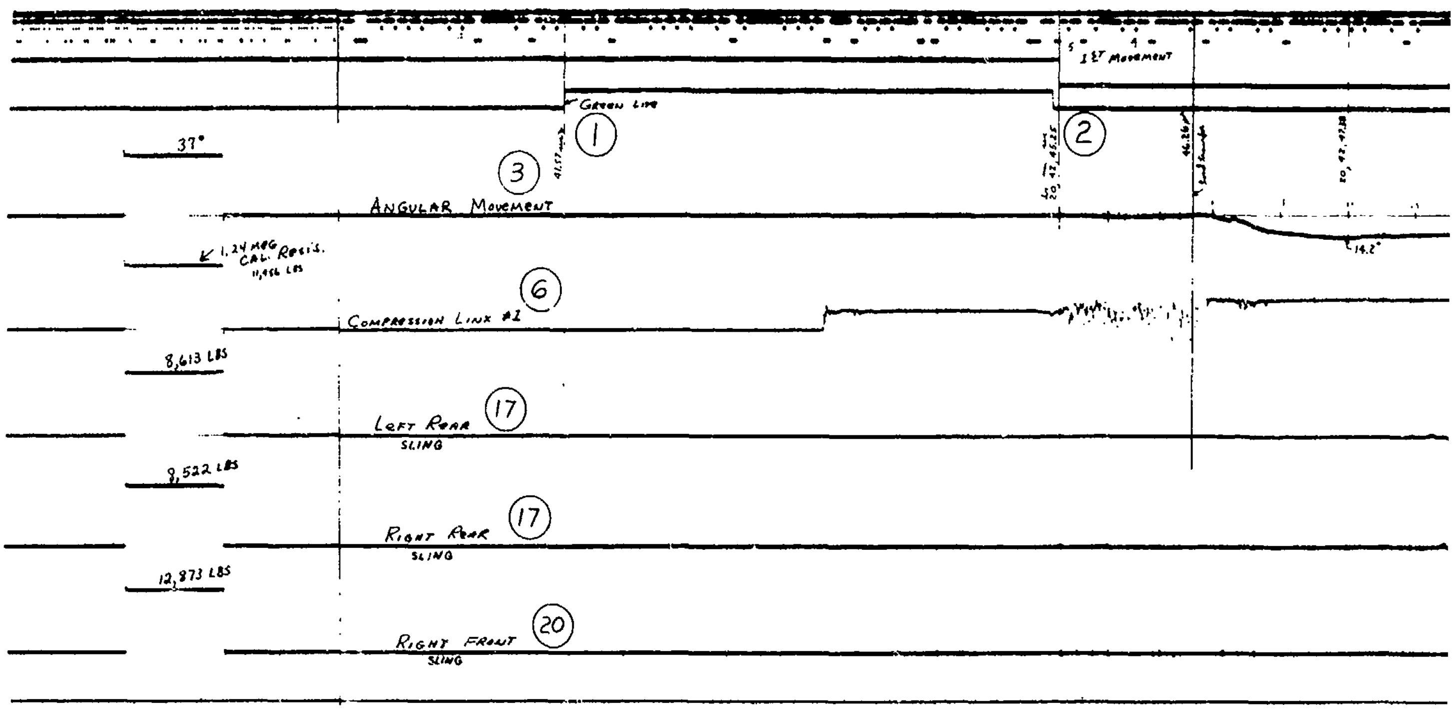
TEST NO. 1


SLO-CODE R/T
GREEN LITE
13' MOVEMENT
1
2
1726 μ INCHES
RT REAR - ALUM. 10
1726 μ INCHES
LEFT REAR. - ALUM. 10
1726 μ INCHES
RT FRONT - ALUM. 16
1726 μ INCHES
LEFT FRONT - ALUM. 16


SLO-CODE TIME OF DAY
13' MOVEMENT
GREEN LITE
1
2
9 RIGHT REAR STEEL FRAME
1726 μ INCHES/IN.
9 LEFT REAR STEEL FRAME
1726 μ INCHES/IN.
15 RIGHT FRONT STEEL FRAME
1726 μ INCHES/IN
15 LEFT FRONT STEEL FRAME
1726 μ INCHES/IN

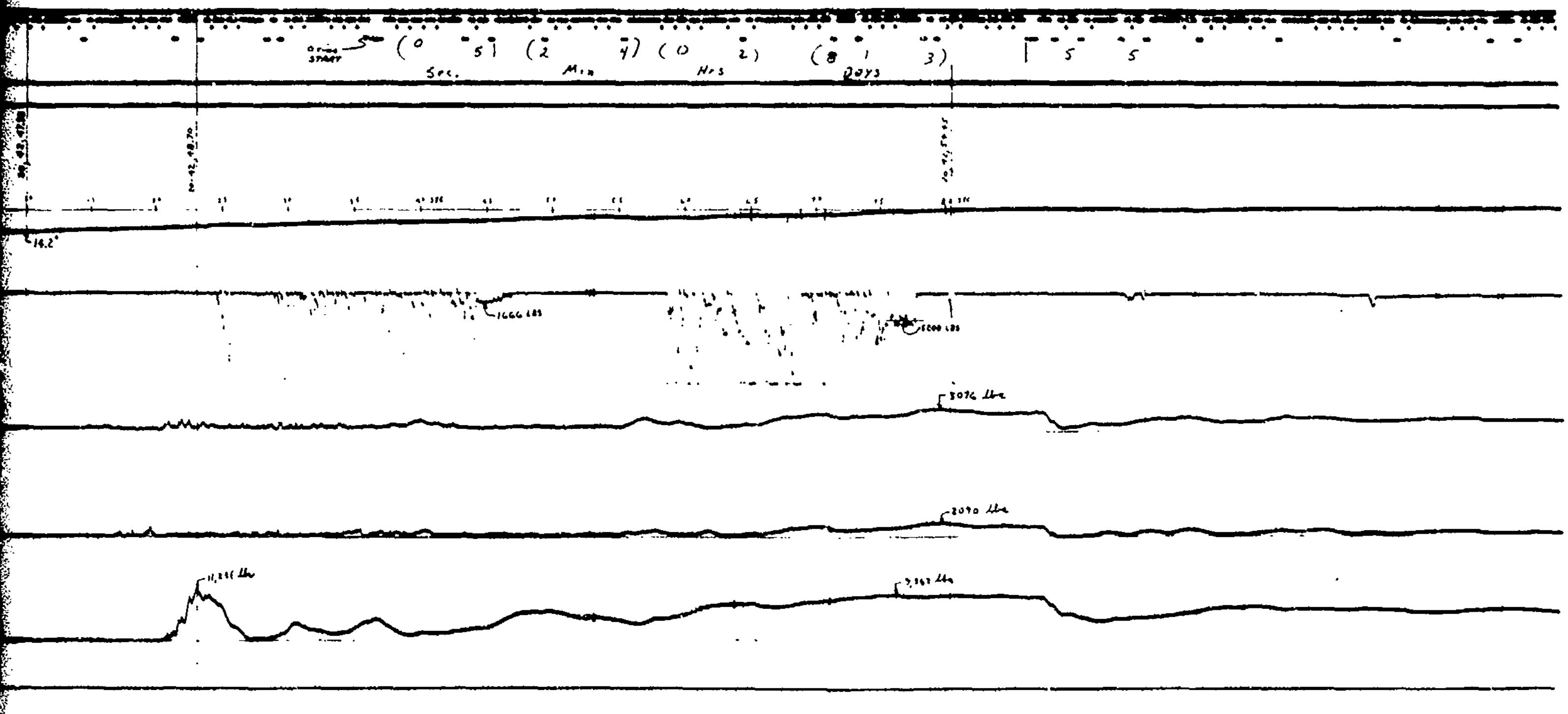

Noise Due To Broken TM Ant. Coax. Cable
Noise Due To Broken T.M. Antenna Coax. Cable

2

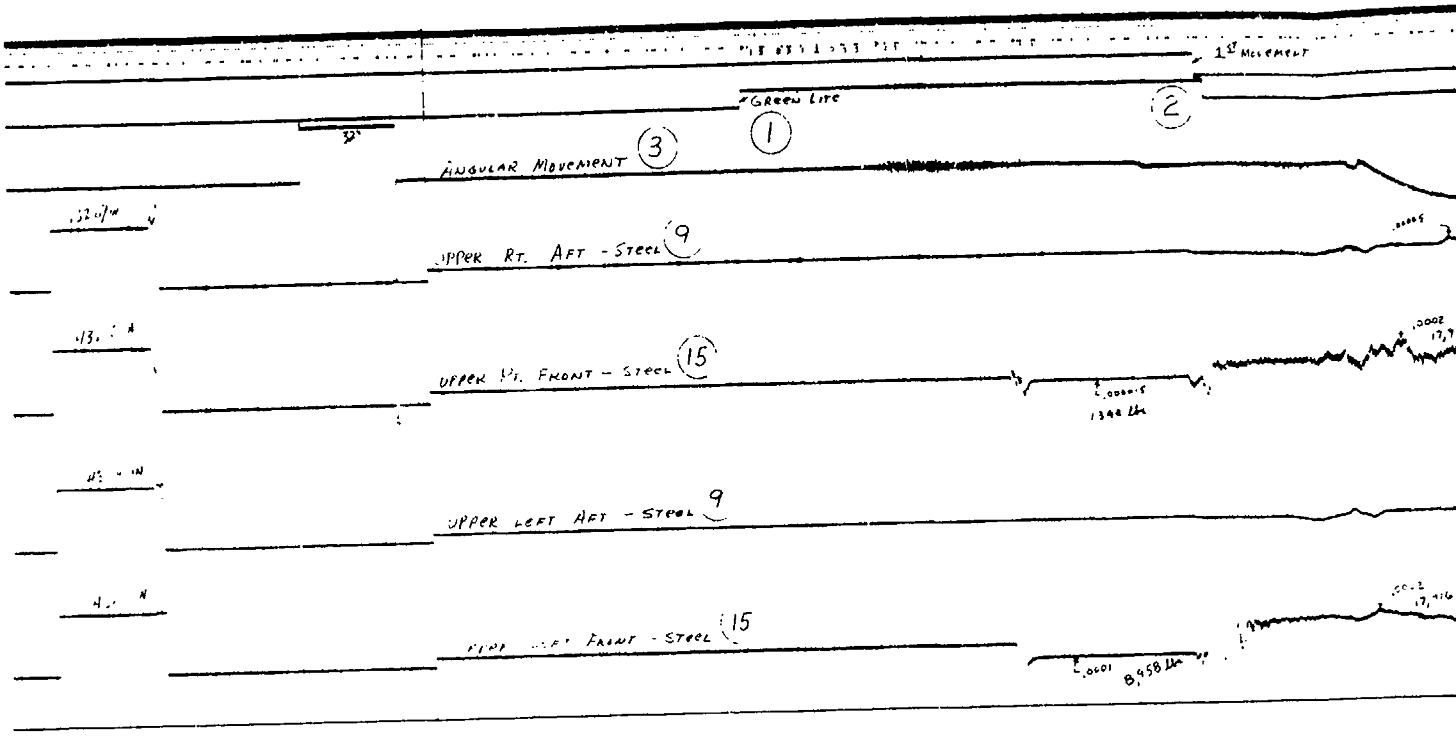


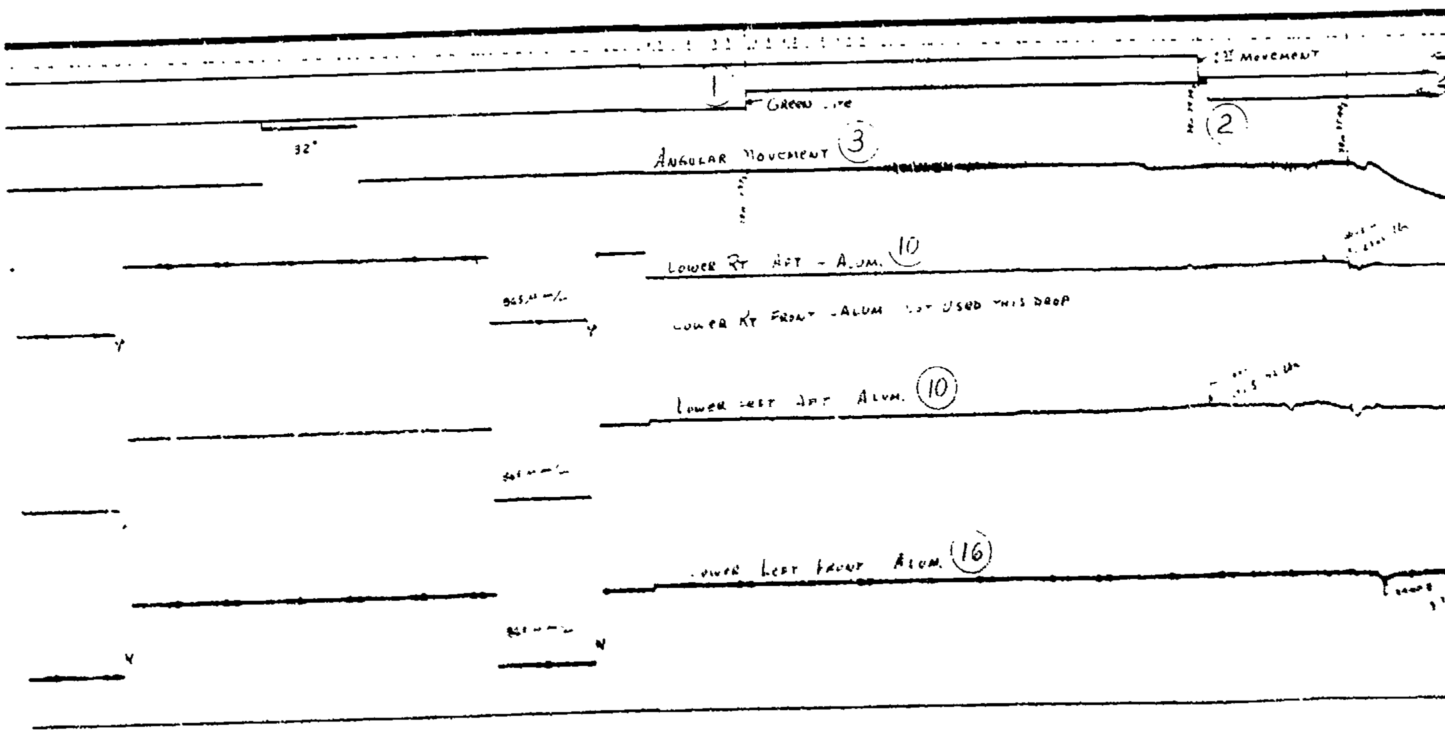
Green Line
1
2
1st Movement
3
37°
Angular Movement
14.2°
1.24 Meg Cal. Resis.
11,456 LBS
6
Compression Link #1
8,613 LBS
17
Left Rear
Sling
8,522 LBS
17
Right Rear
Sling
12,873 LBS
20
Right Front
Sling

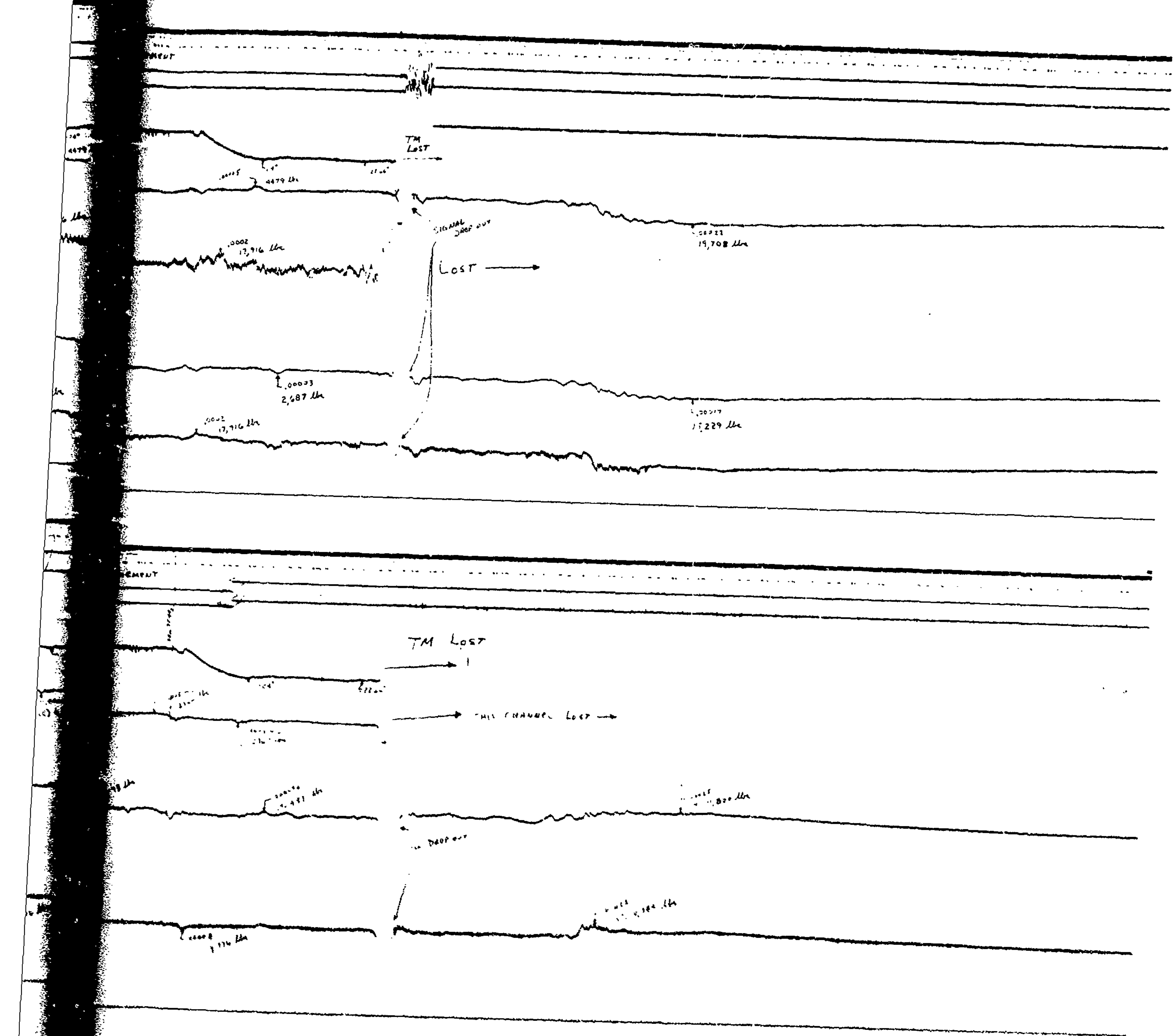
/



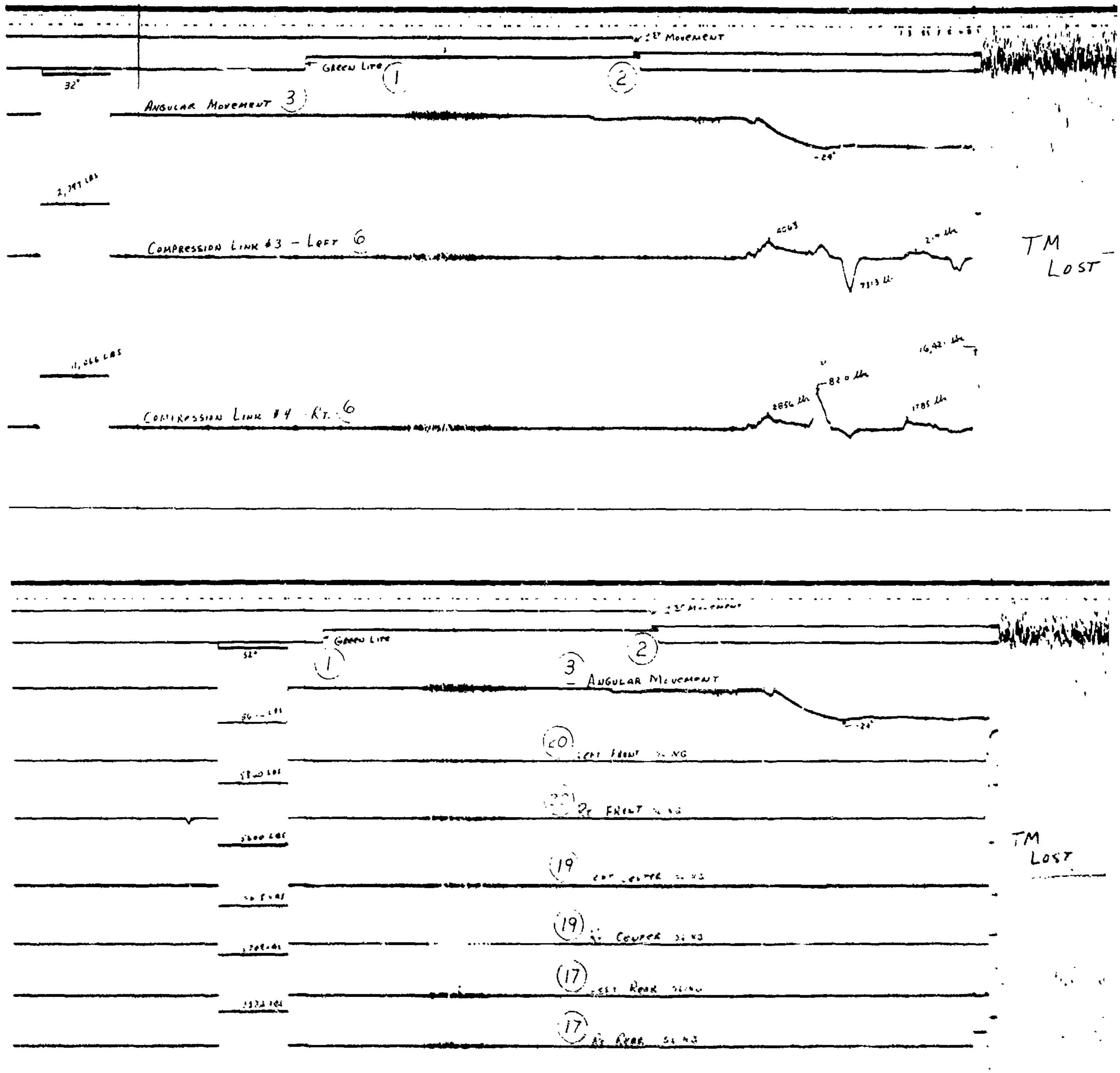
TEST NO. 2 - SHT. NO. 2


1st Movement
Green Lite
1
2
Angular Movement 3
Upper Rt. Aft - Steel 9
Upper Rt. Front - Steel 15
Upper Left Aft - Steel 9
Left Front - Steel 15


1st Movement
1
Green Lite
2
32°
Angular Movement 3
Lower Rt Aft - Alum. 10
Lower Rt Front - Alum not used this drop
Lower Left Aft Alum. 10
Lower Left Front Alum. 16

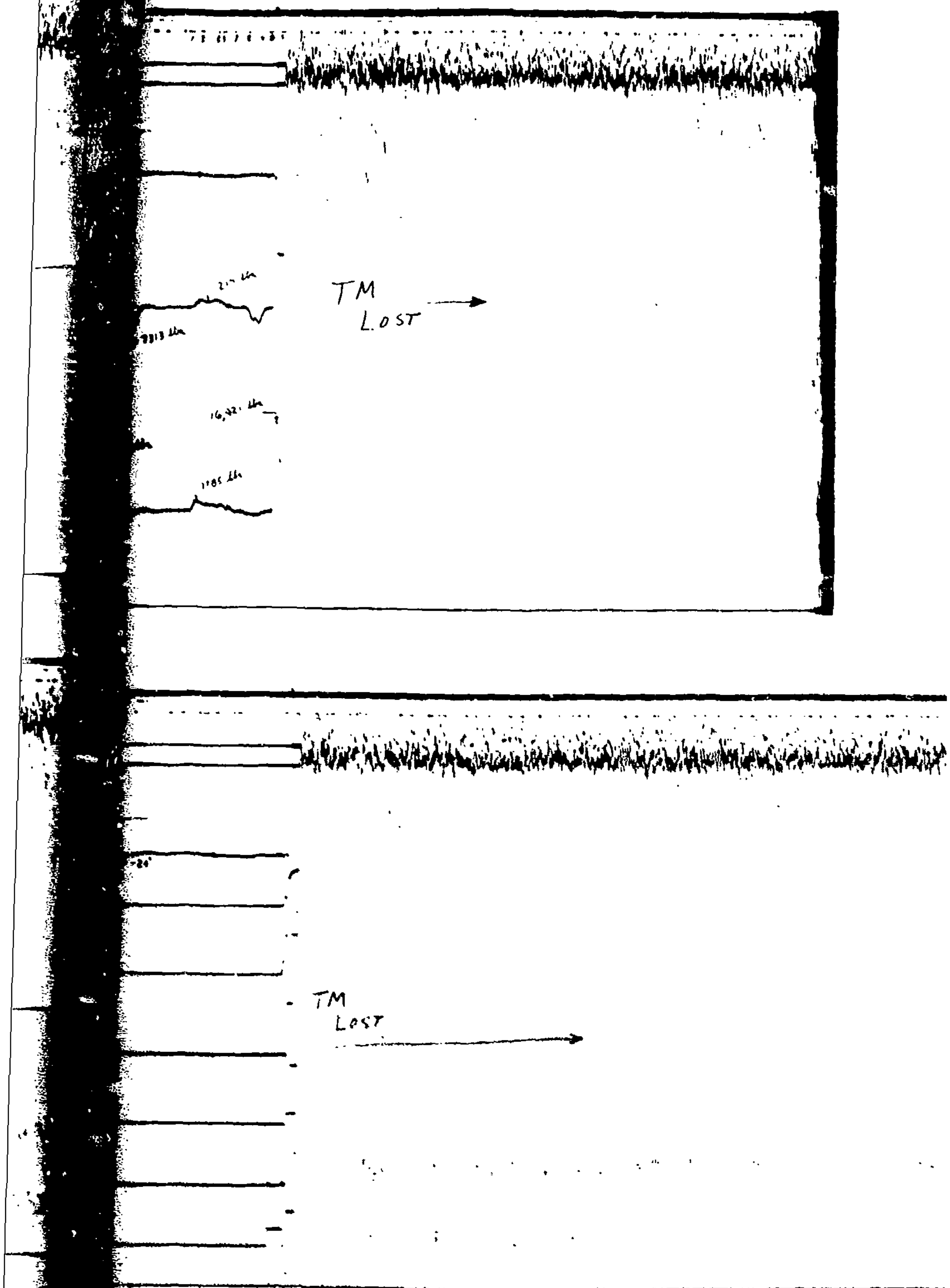


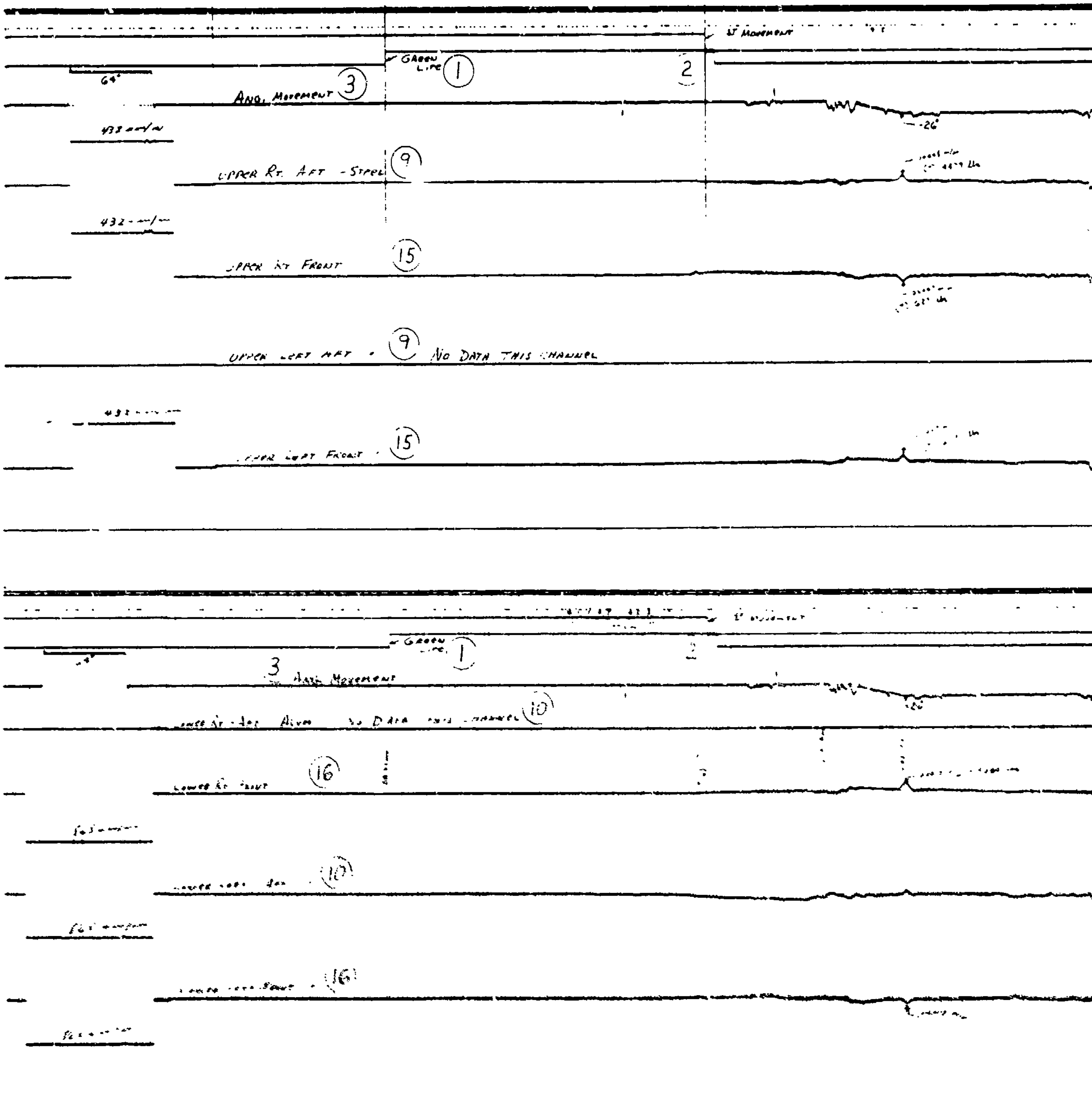
TEST NO. 4 - SHT. NO. 1



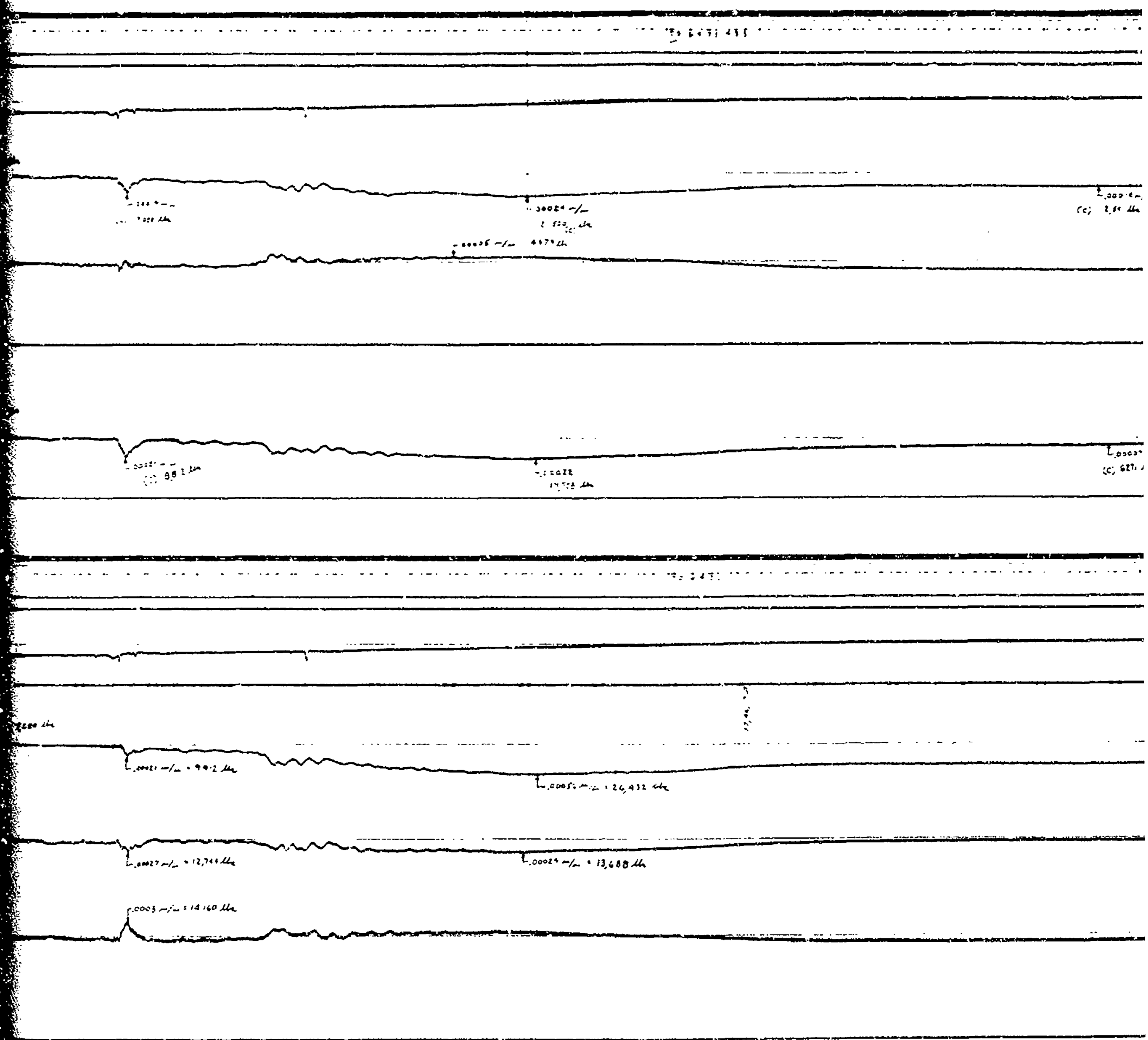
2^0 MOVEMENT
GREEN LITE
1
2
32°
ANGULAR MOVEMENT 3
-24°
COMPRESSION LINK #3 - LEFT 6
TM LOST
COMPRESSION LINK #4 RT. 6
2^0 MOVEMENT
GREEN LITE
1
2
3
ANGULAR MOVEMENT
-24°
20
RT FRONT
19
19
CENTER
17
LEFT REAR
17
RT REAR
TM LOST

TE

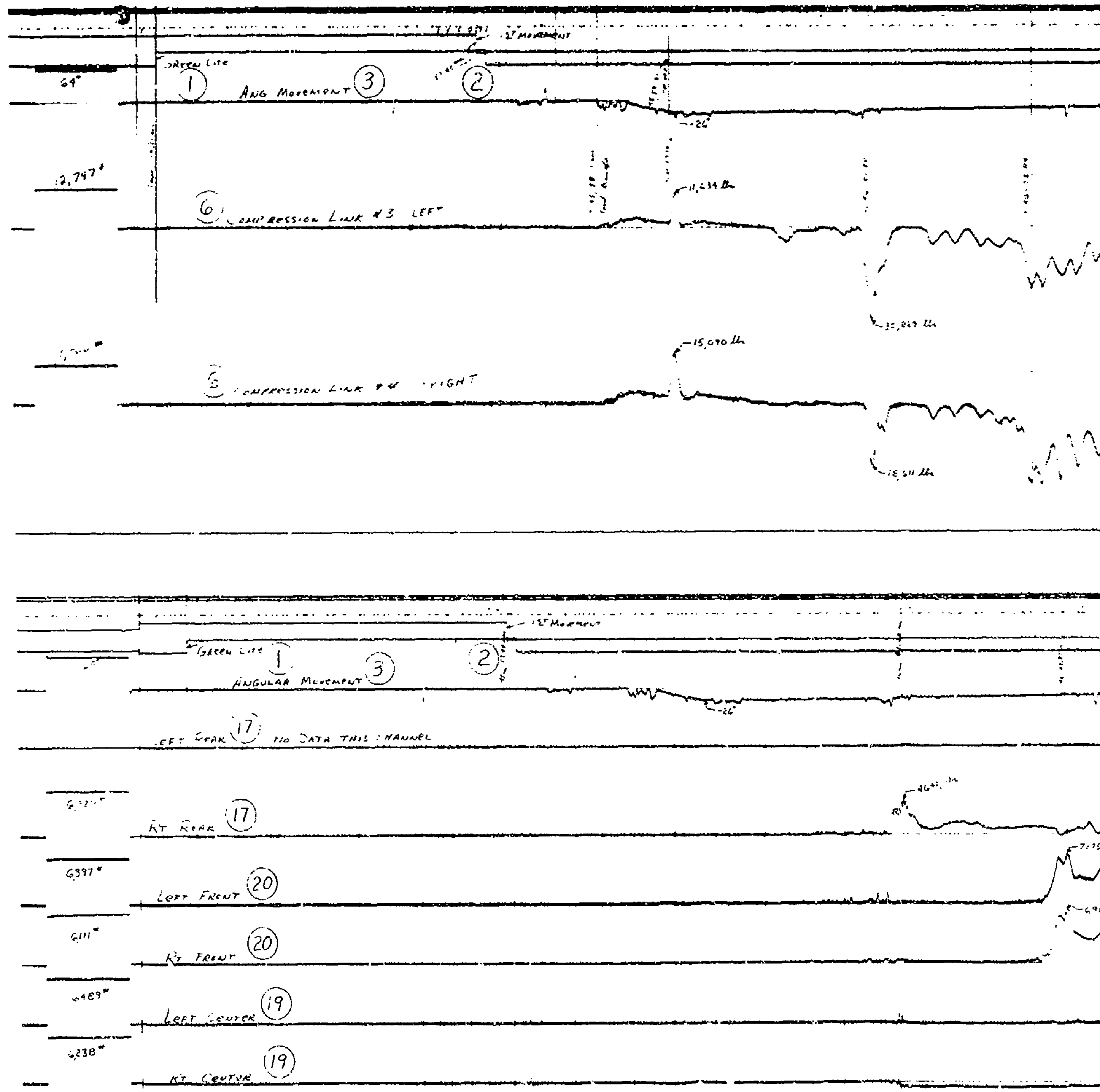

TM
LOST
TM
LOST



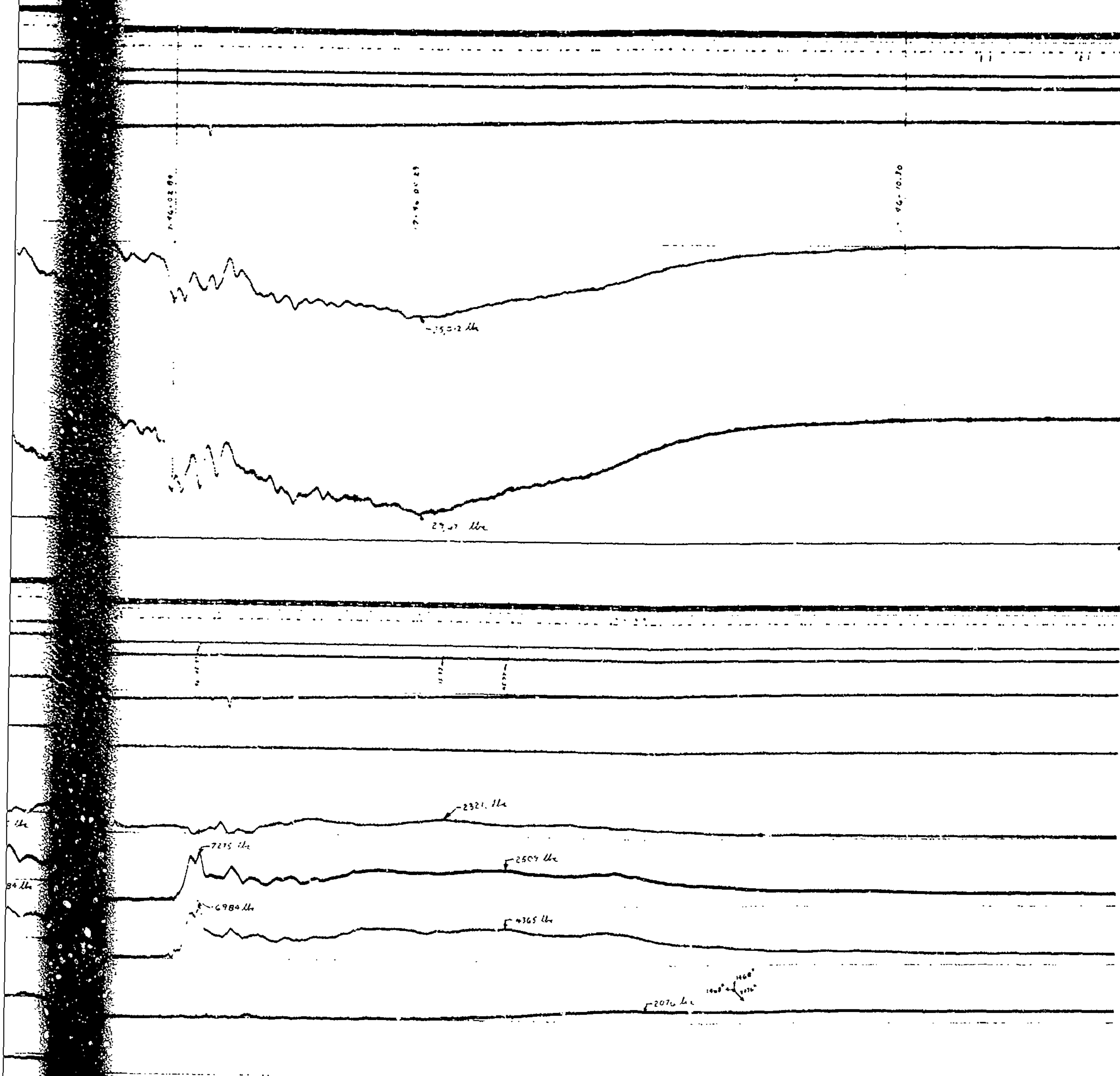
GREEN LITE
1
2
64°
3
ANG. MOVEMENT
-26°
UPPER RT. AFT - STEEL
9
432
UPPER RT FRONT
15
UPPER LEFT AFT
9
NO DATA THIS CHANNEL
UPPER LEFT FRONT
15
GREEN LITE
1
2
3
ANG. MOVEMENT
NO DATA
10
LOWER RT FRONT
16
10
16



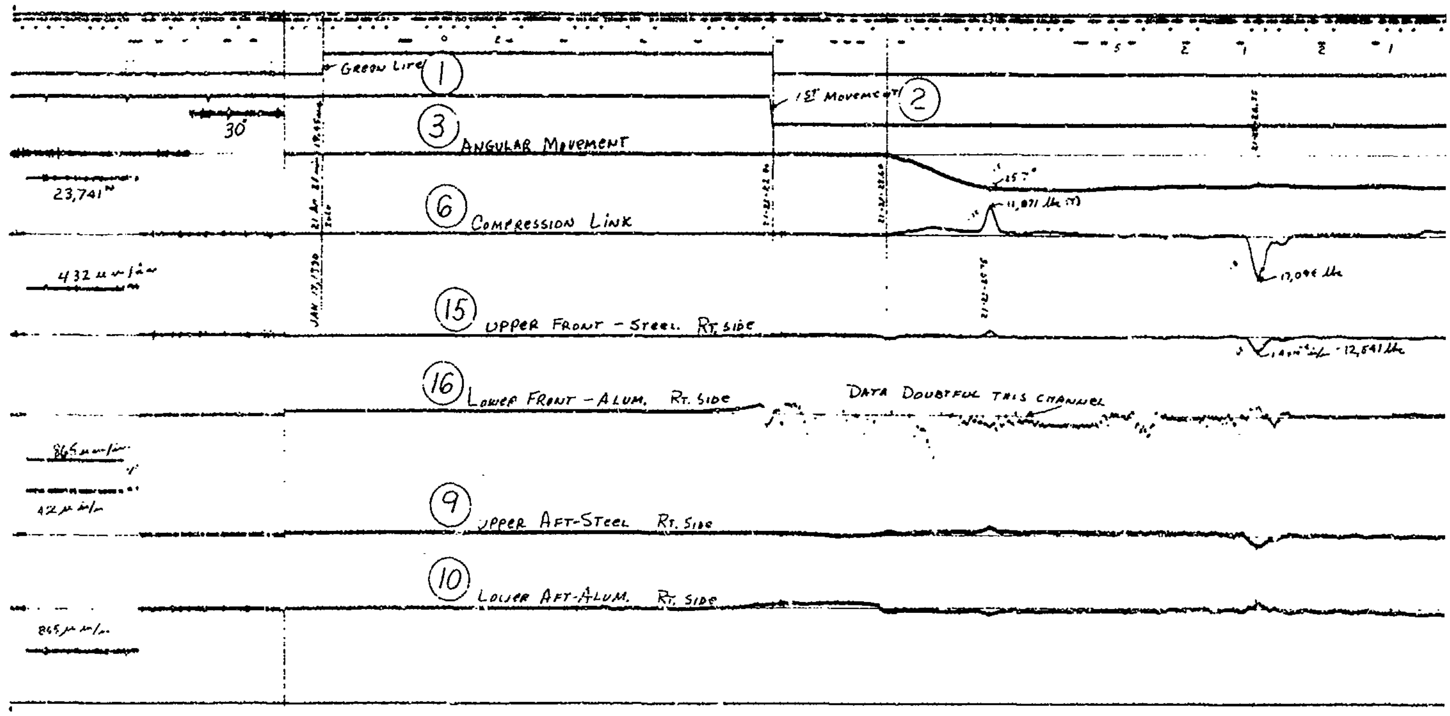
TEST NO. 5 - SHT. NO. 1



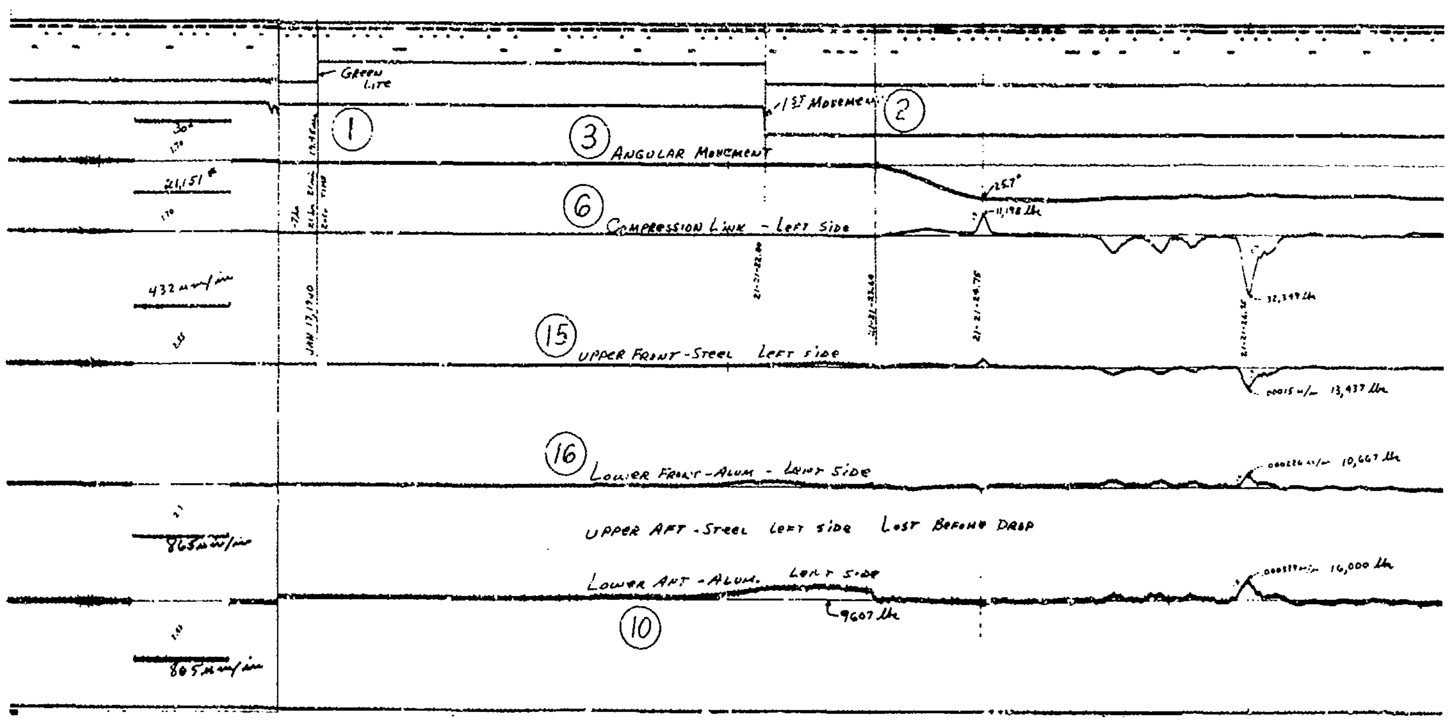
.15" Movement
Green Lite
64°
1
Ang Movement
3
2
-26°
12,747#
6
Compression Link #3 Left
11,439 lbs
30,049 lbs
15,090 lbs
Compression Link #4 Right
18,511 lbs
.15" Movement
Green Lite
1
Angular Movement
3
2
-26°
Left Rear
17
No Data This Channel
Rt Rear
17
6397#
Left Front
20
6111#
Rt Front
20
6469#
Left Center
19
6238#
Rt Center
19



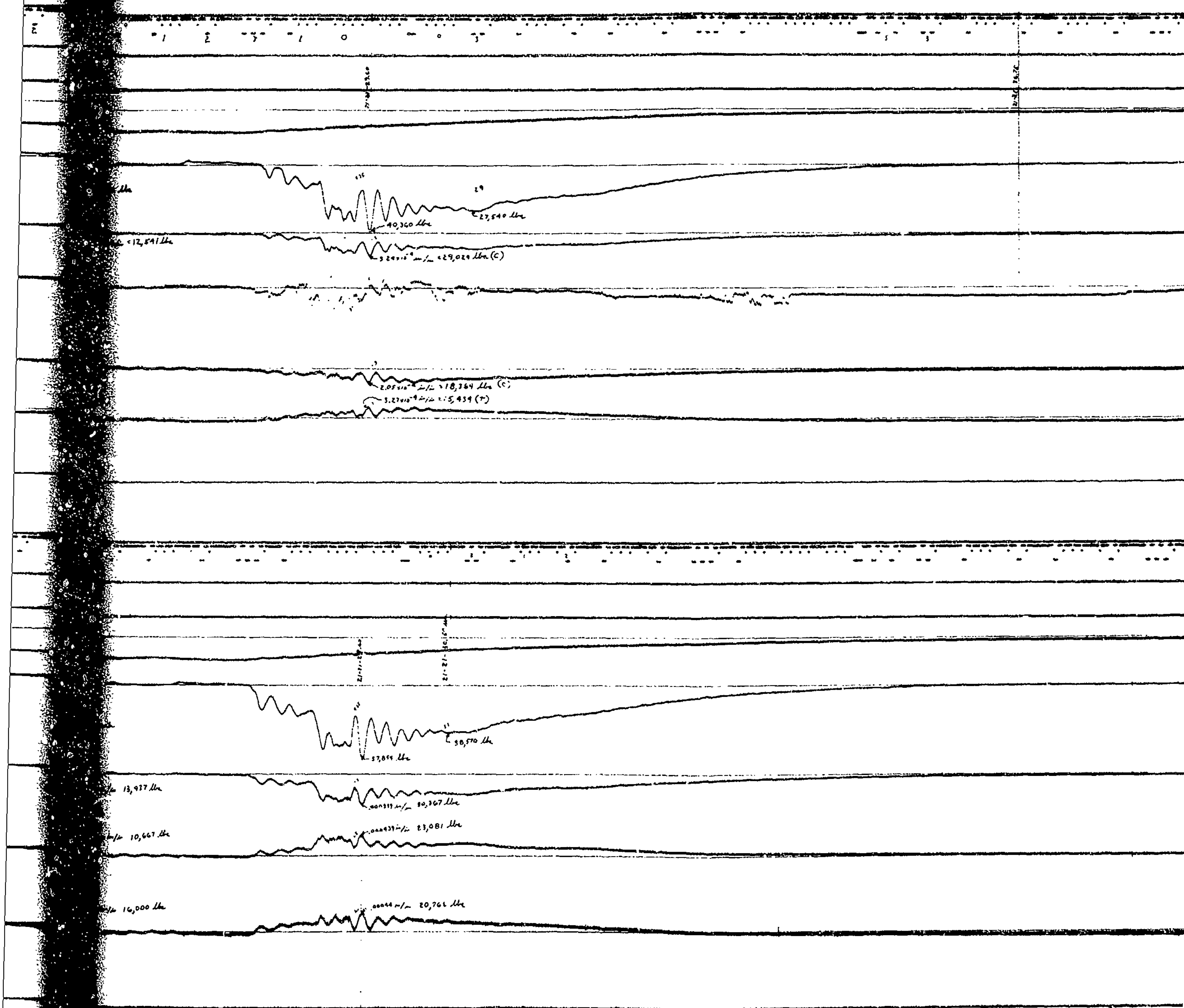
TEST NO. 5 - SHT. NO. 2



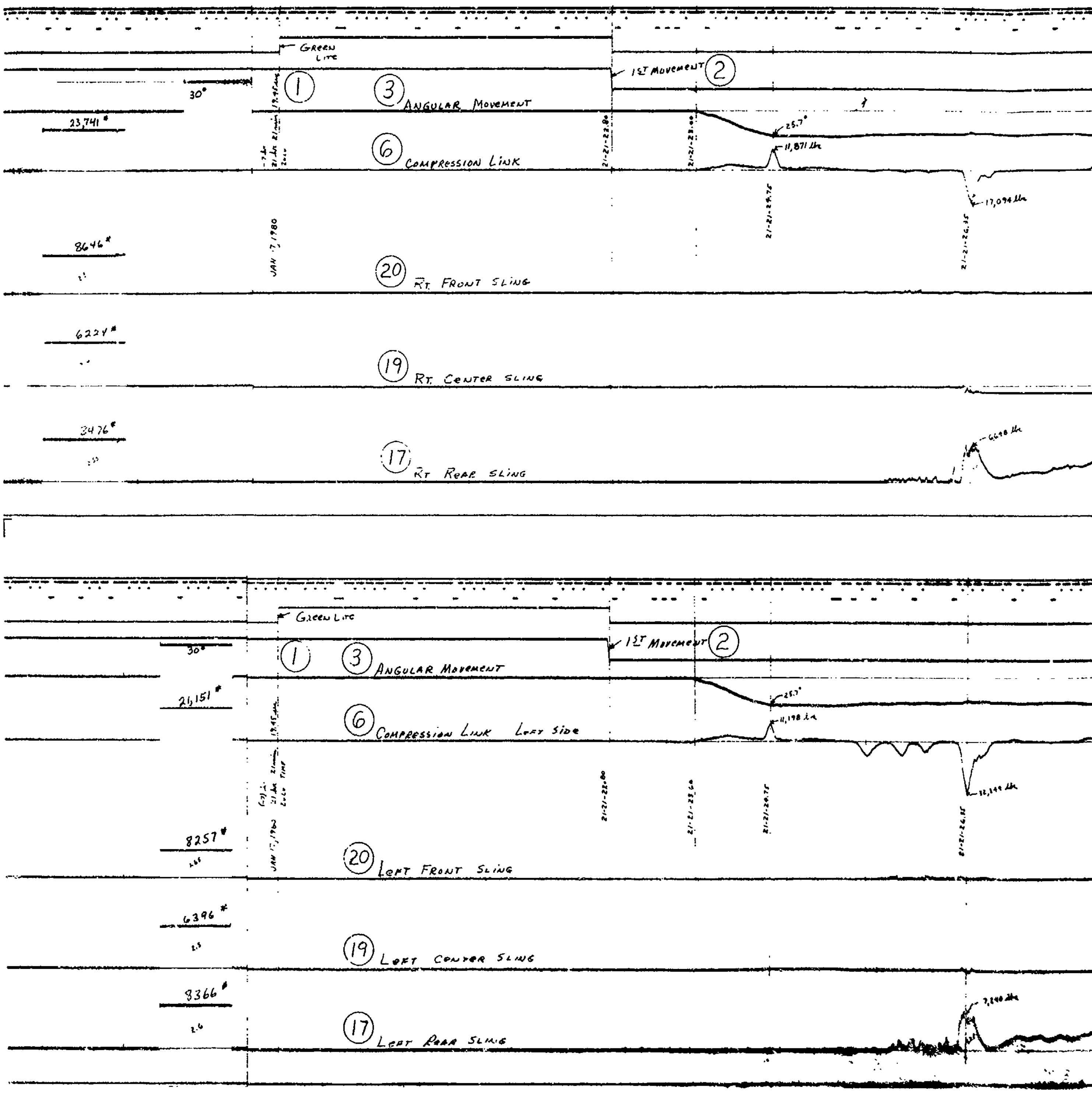
GREEN LITE
1
1ST MOVEMENT
2
30°
3 ANGULAR MOVEMENT
23,741
25.7°
11,871 lb
6 COMPRESSION LINK
432 μ in/in
JAN. 17, 1950
17,096 lb
15 UPPER FRONT - STEEL RT. SIDE
12,541 lb
16 LOWER FRONT - ALUM. RT. SIDE
DATA DOUBTFUL THIS CHANNEL
865 μ in/in
432 μ in/in
9 UPPER AFT-STEEL RT. SIDE
10 LOWER AFT-ALUM. RT. SIDE
865 μ in/in



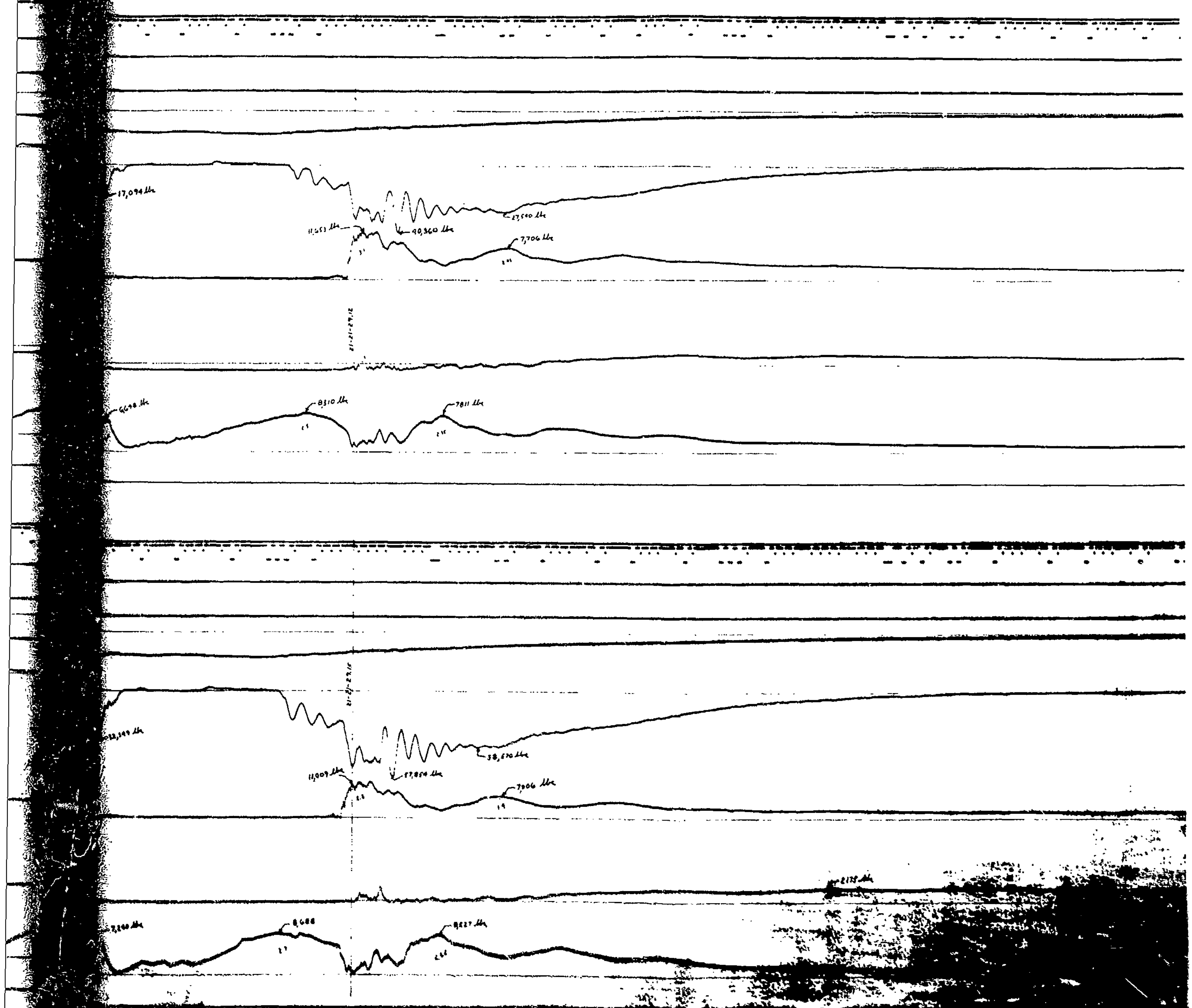
GREEN LITE
1ST MOVEMENT
2
30°
1
3 ANGULAR MOVEMENT
21,151
25.7°
11,198 lb
6 COMPRESSION LINK - LEFT SIDE
432 μ in/in
JAN. 17, 1950
32,349 lb
15 UPPER FRONT - STEEL LEFT SIDE
13,437 lb
16 LOWER FRONT - ALUM - LEFT SIDE
10,667 lb
UPPER AFT - STEEL LEFT SIDE LOST BEFORE DROP
865 μ in/in
LOWER AFT - ALUM. LEFT SIDE
16,000 lb
9607 lb
10
865 μ in/in



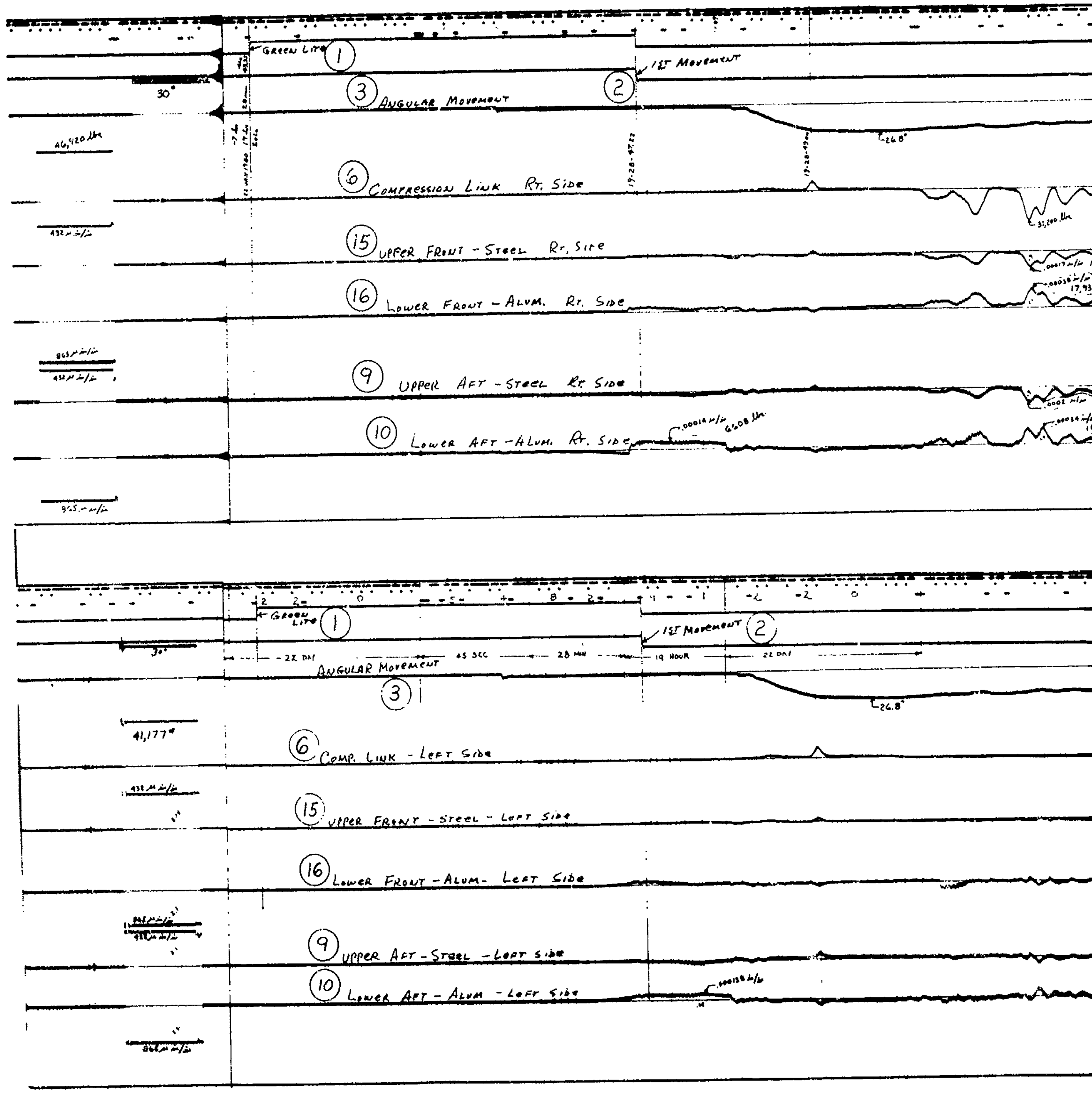
TEST NO. 6 - SHT. NO. 1



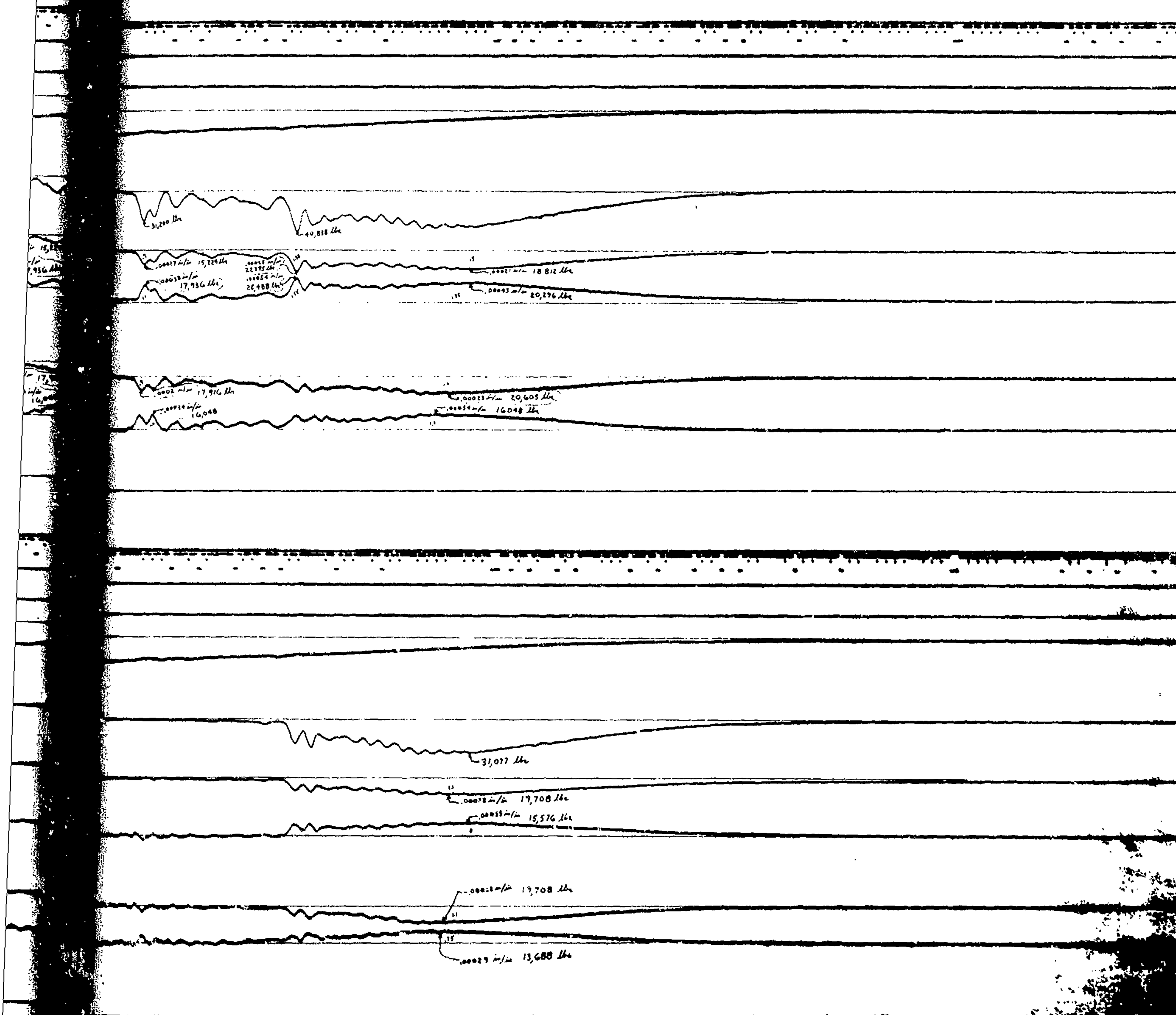
GREEN LITE
1ST MOVEMENT
2
1
3 ANGULAR MOVEMENT
30°
23,741 #
25.7°
6 COMPRESSION LINK
11,871 lbs
17,094 lbs
JAN 17, 1980
8646 #
20 RT. FRONT SLING
6224 #
19 RT. CENTER SLING
3476 #
17 RT. REAR SLING
GREEN LITE
1ST MOVEMENT
2
1
3 ANGULAR MOVEMENT
30°
21,151 #
25.7°
6 COMPRESSION LINK LEFT SIDE
8257 #
20 LEFT FRONT SLING
6396 #
19 LEFT CENTER SLING
3366 #
17 LEFT REAR SLING



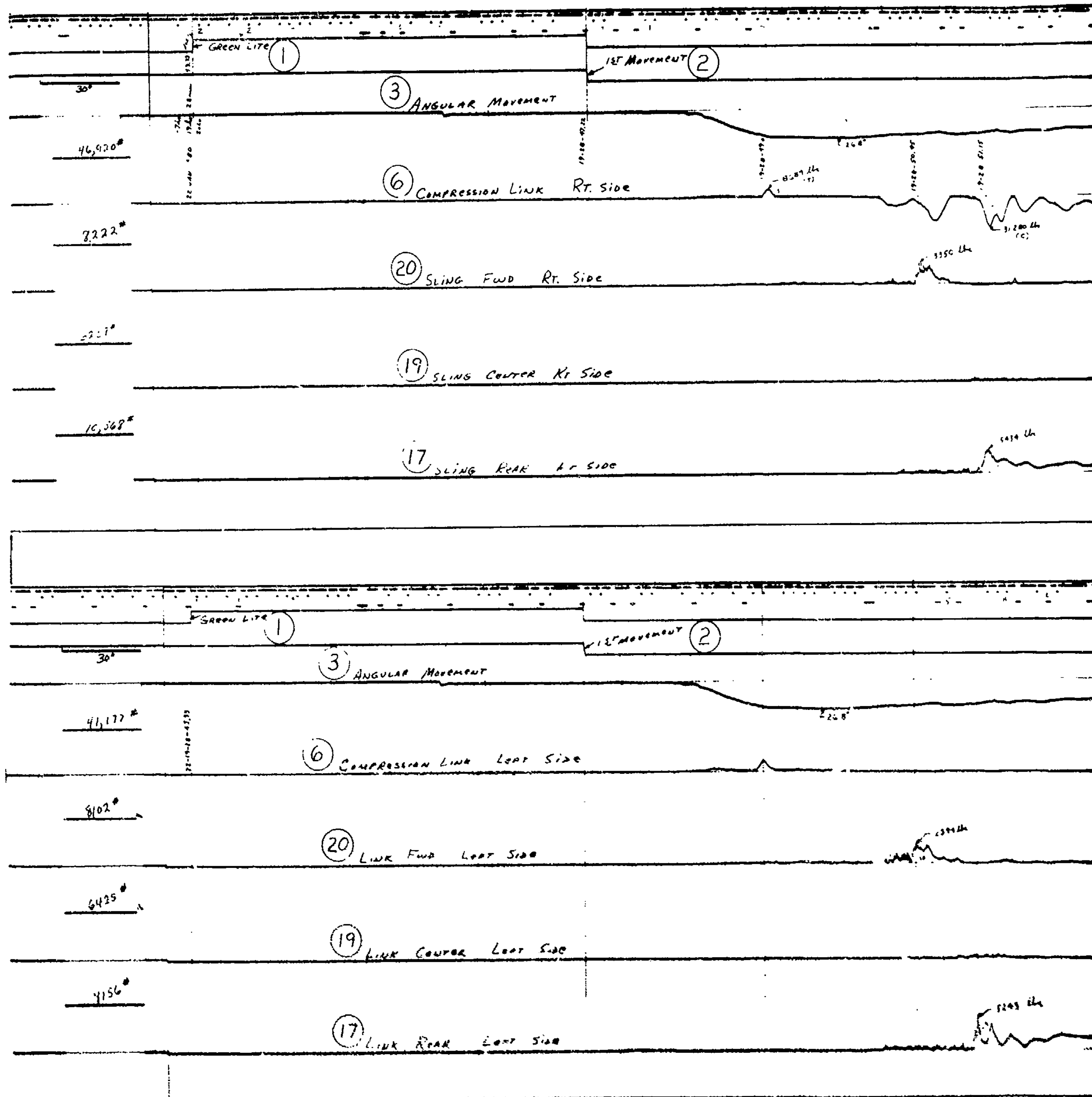
TEST NO. 6 - SHT. NO. 2



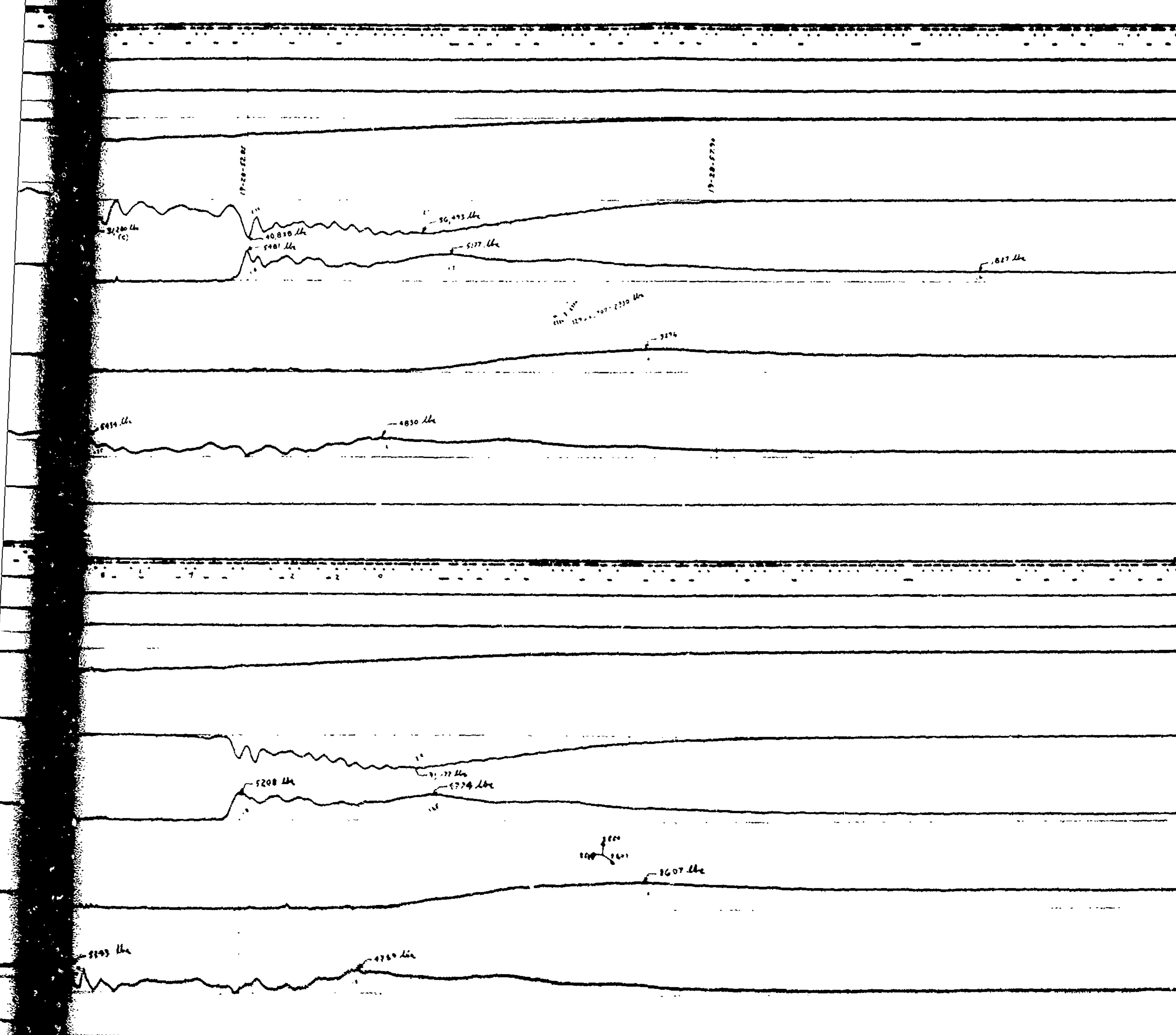
30°
46,920 lbs
GREEN LITE (1)
1ST MOVEMENT (2)
(3) ANGULAR MOVEMENT
26.8°
(6) COMPRESSION LINK RT. SIDE
31,200 lbs
(15) UPPER FRONT - STEEL RT. SIDE
(16) LOWER FRONT - ALUM. RT. SIDE
(9) UPPER AFT - STEEL RT. SIDE
(10) LOWER AFT - ALUM. RT. SIDE
6608 lbs
GREEN LITE (1)
1ST MOVEMENT (2)
22 DAY
45 SEC
28 MIN
19 HOUR
22 DAY
ANGULAR MOVEMENT (3)
26.8°
41,177#
(6) COMP. LINK - LEFT SIDE
(15) UPPER FRONT - STEEL - LEFT SIDE
(16) LOWER FRONT - ALUM - LEFT SIDE
(9) UPPER AFT - STEEL - LEFT SIDE
(10) LOWER AFT - ALUM - LEFT SIDE



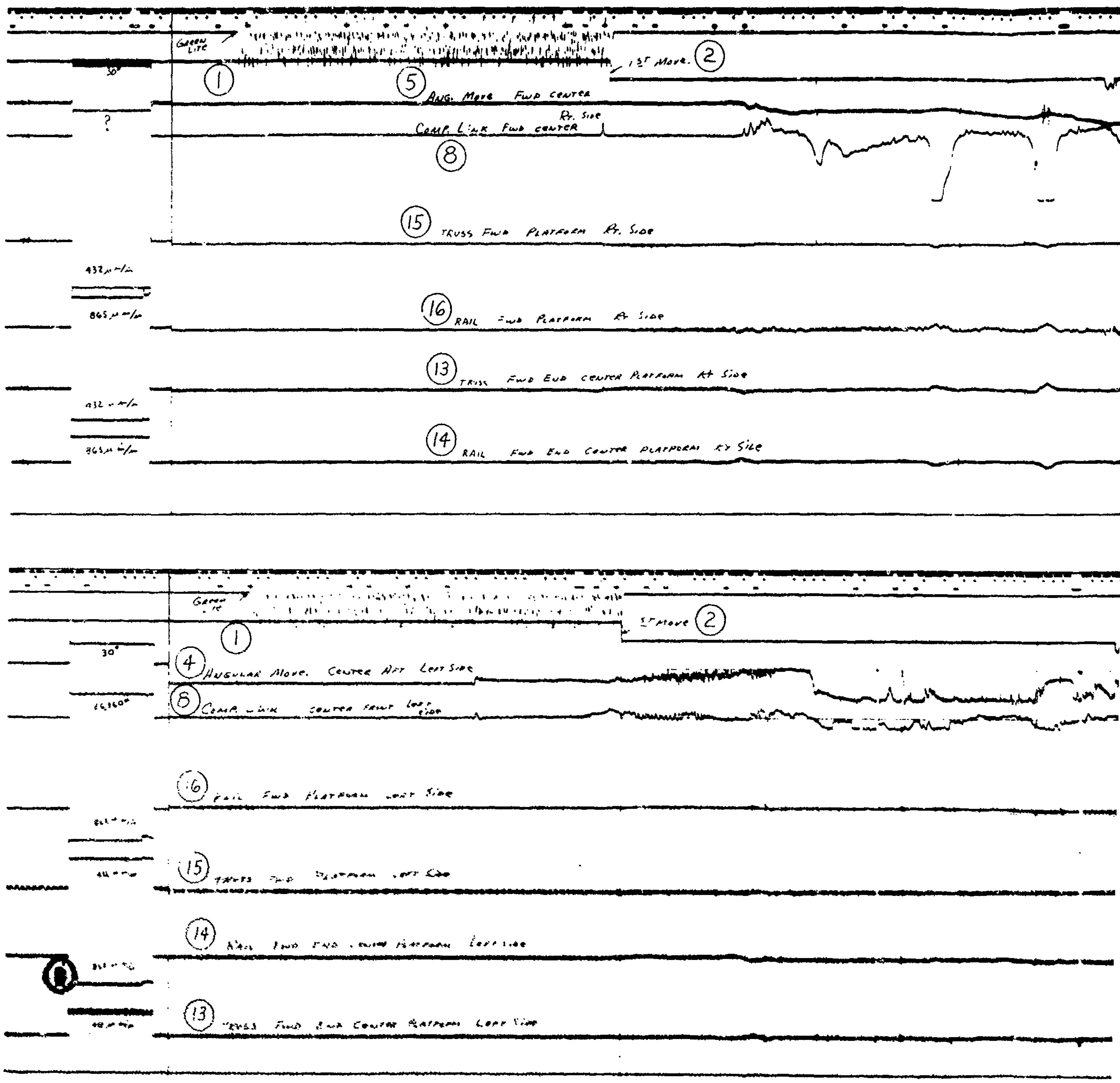
TEST NO. 7 - SHT. NO. 1



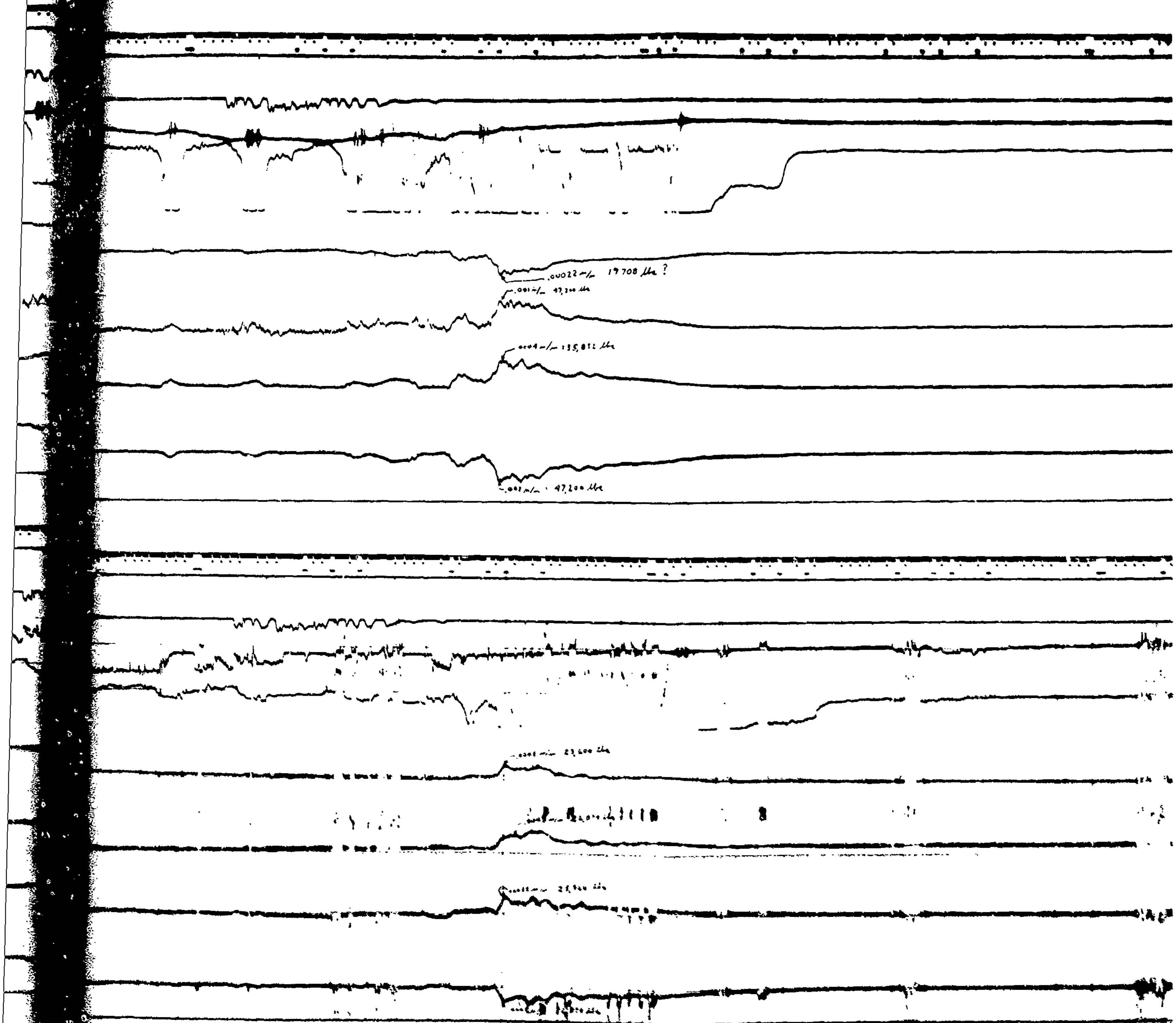
GREEN LITE
1ST MOVEMENT
30°
ANGULAR MOVEMENT
46,920#
COMPRESSION LINK RT. SIDE
SLING FWD RT. SIDE
SLING CENTER RT SIDE
10,568#
SLING REAR RT SIDE
GREEN LITE
1ST MOVEMENT
30°
ANGULAR MOVEMENT
41,177#
COMPRESSION LINK LEFT SIDE
8102#
LINK FWD LEFT SIDE
LINK CENTER LEFT SIDE
LINK REAR LEFT SIDE



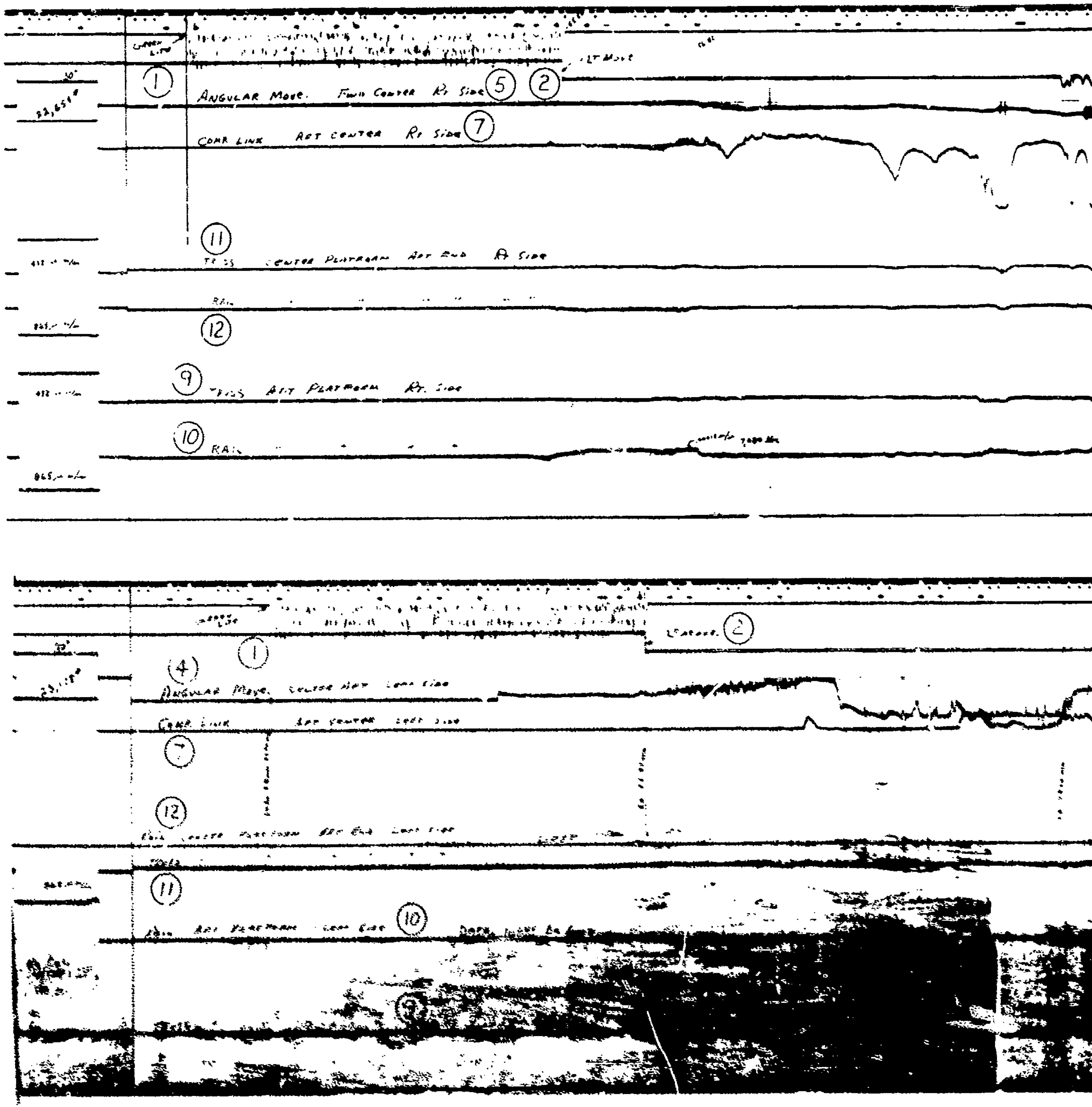
TEST NO. 7 - SHT. NO. 2

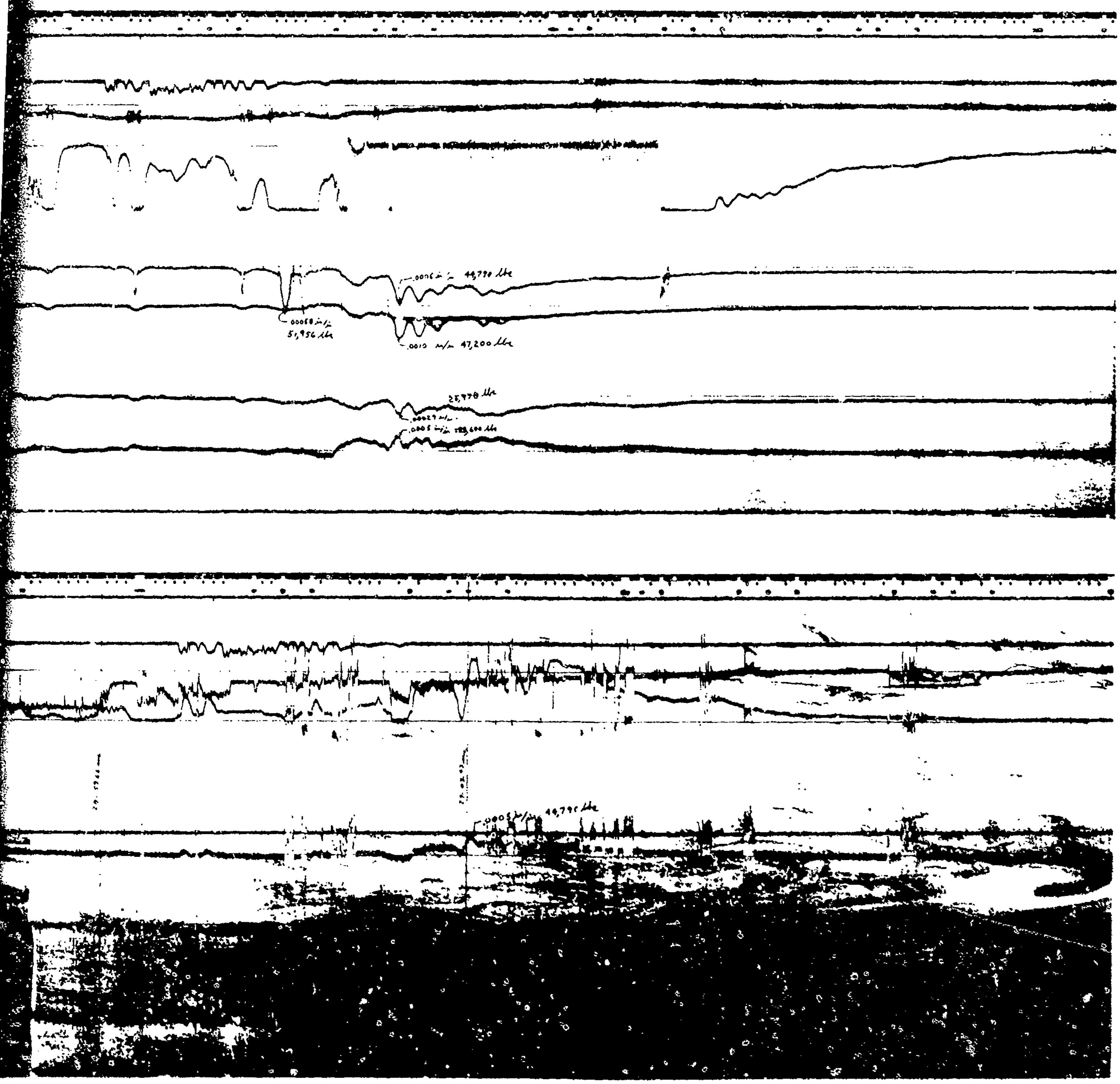


GREEN LITE
1
1ST MOVE
2
30°
5
ANG. MOVE FWD CENTER
?
COMP. LINK FWD CENTER RT. SIDE
8
15
TRUSS FWD PLATFORM RT. SIDE
432 μ in/in
865 μ in/in
16
RAIL FWD PLATFORM RT SIDE
13
TRUSS FWD END CENTER PLATFORM RT SIDE
432 μ in/in
865 μ in/in
14
RAIL FWD END CENTER PLATFORM RT SIDE
GREEN LITE
1
1ST MOVE
2
30°
4
ANGULAR MOVE. CENTER AFT LEFT SIDE
8
COMP. LINK CENTER FRONT LEFT SIDE
6
RAIL FWD PLATFORM LEFT SIDE
15
TRUSS FWD PLATFORM LEFT SIDE
14
RAIL FWD END CENTER PLATFORM LEFT SIDE
13
TRUSS FWD END CENTER PLATFORM LEFT SIDE

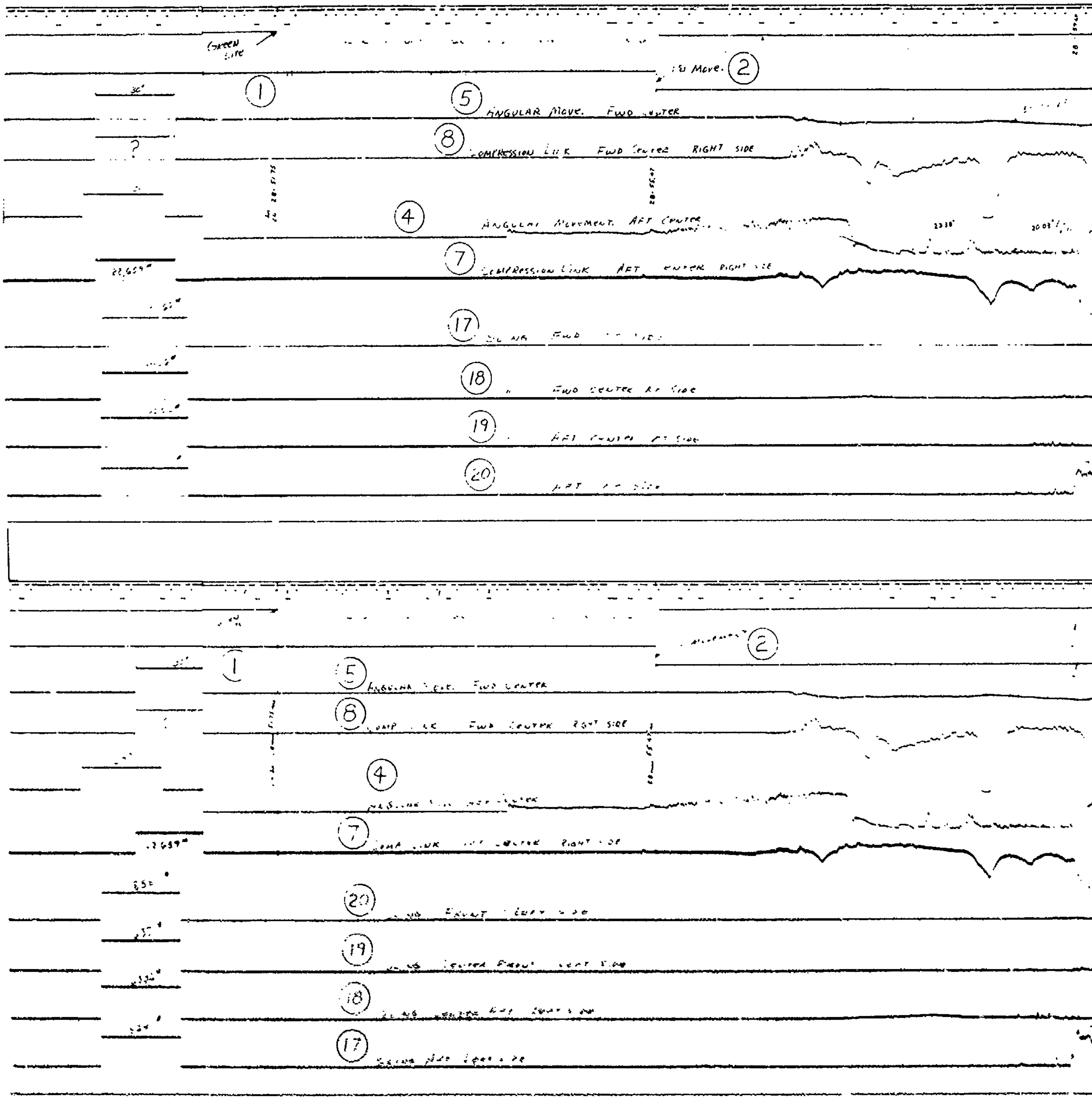


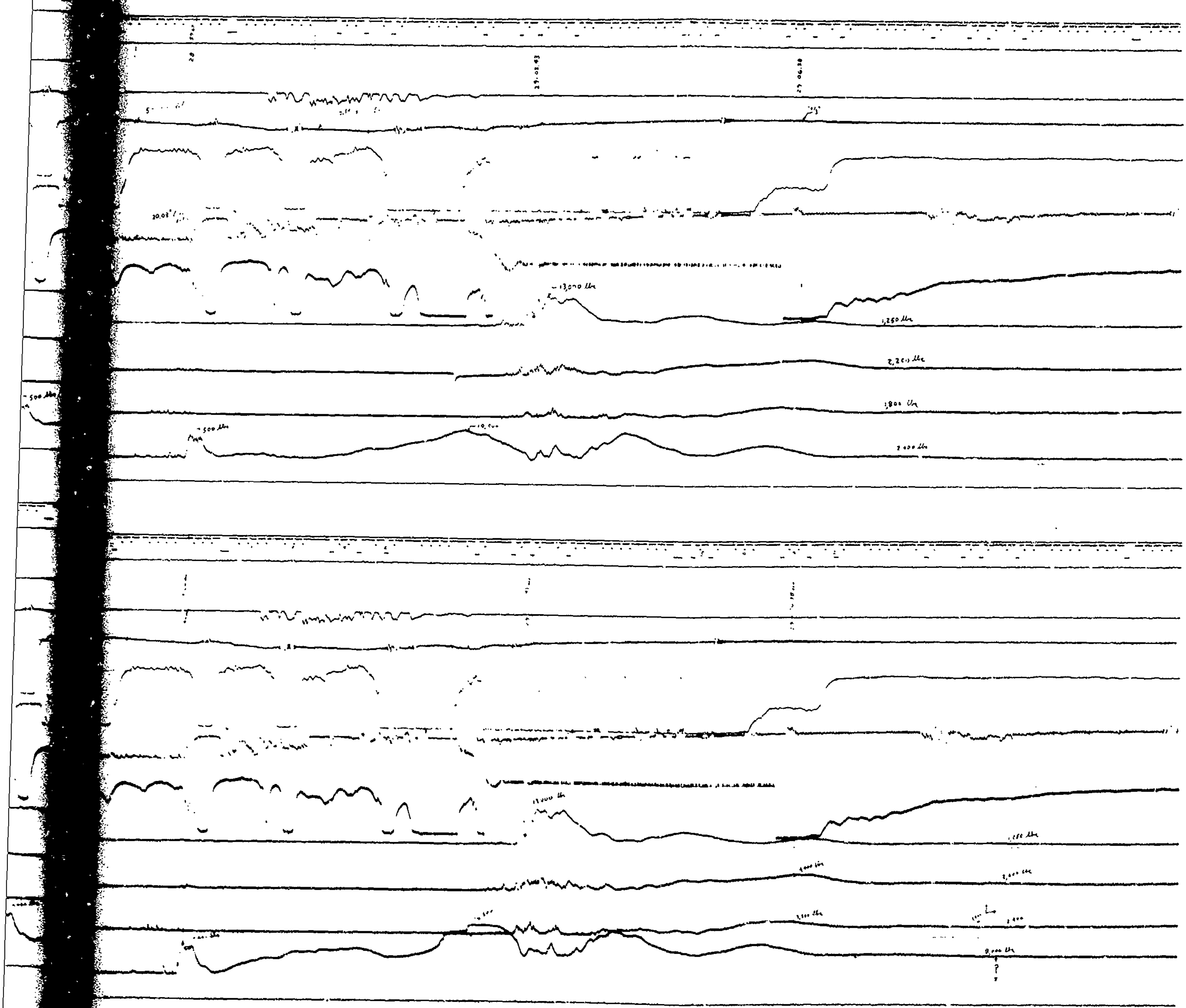
TEST NO. 8 - SHT. NO. 1


ANGULAR MOVE. FWD CENTER RT SIDE
COMP LINK AFT CENTER RT SIDE
CENTER PLATFORM AFT END RT SIDE
RAIL
AFT PLATFORM RT. SIDE
RAIL
ANGULAR MOVE.
COMP. LINK AFT CENTER
AFT PLATFORM

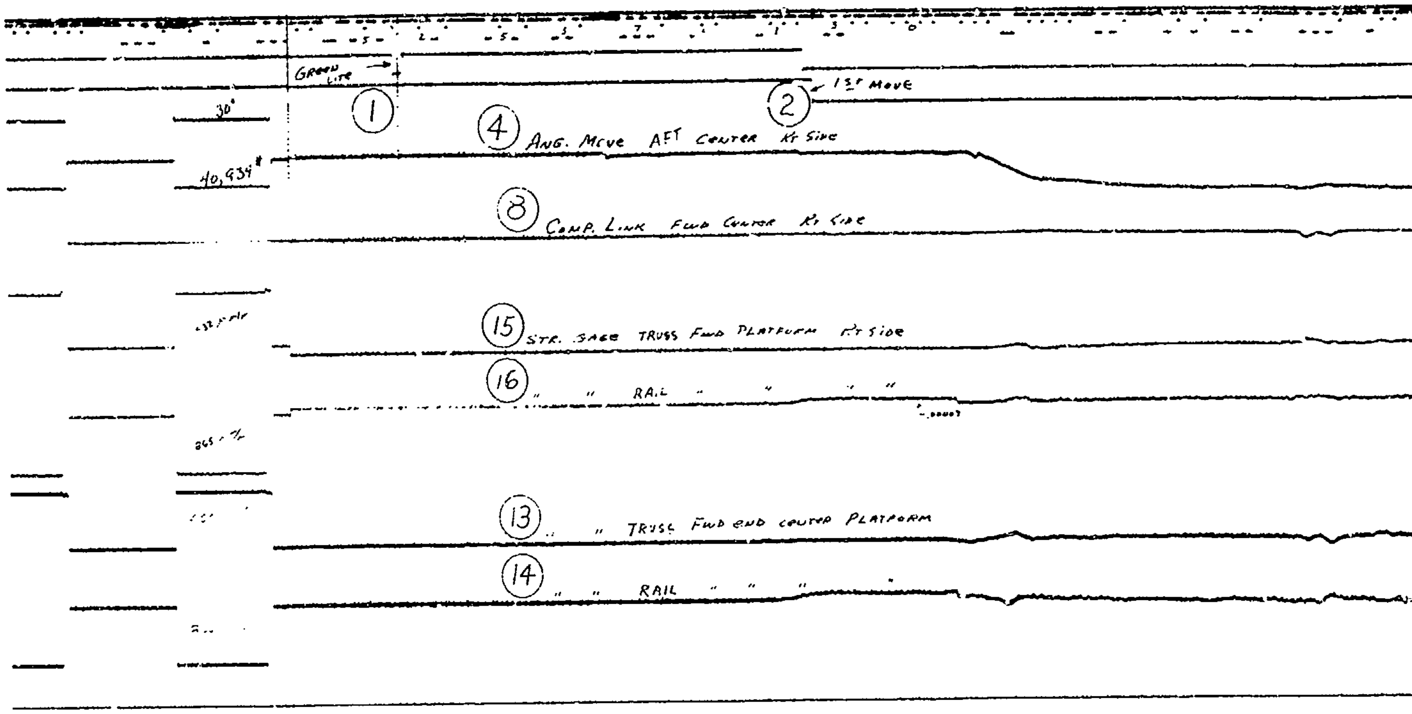


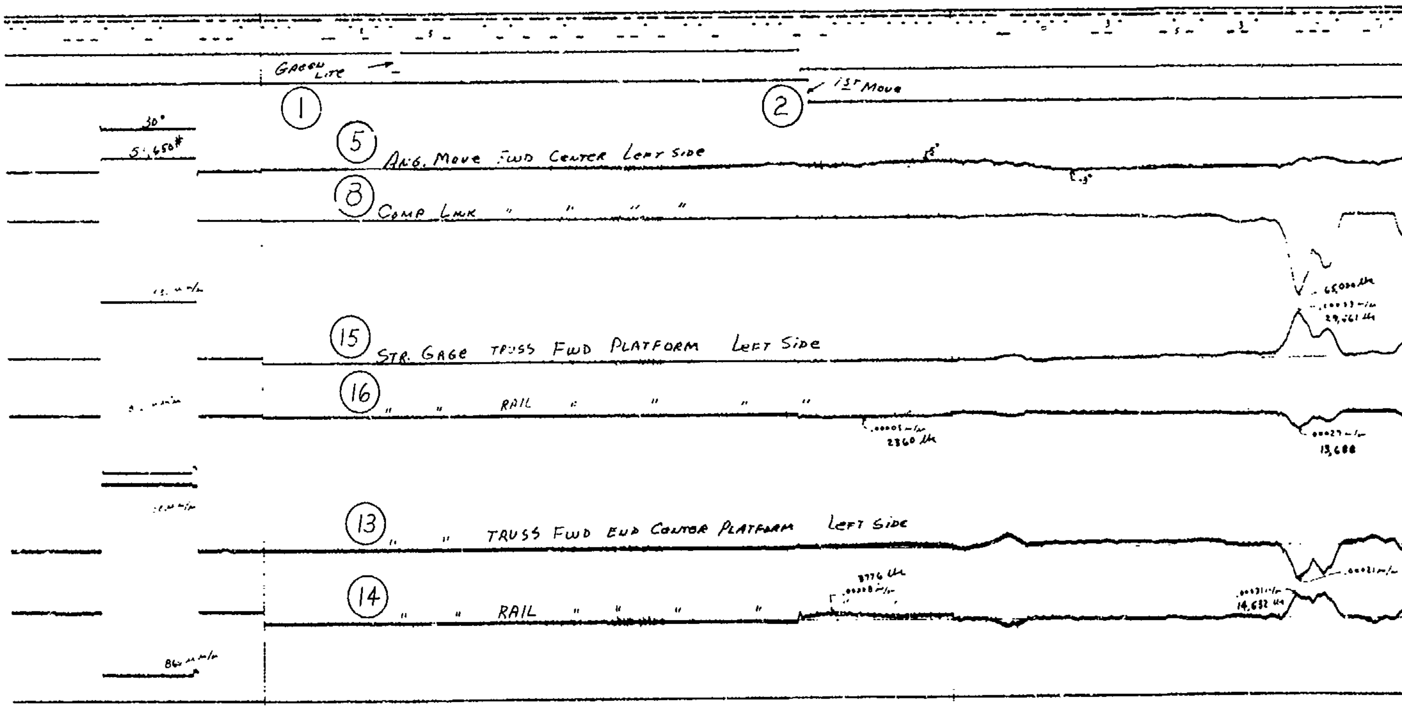
TEST NO. 8 - SHT. NO. 2

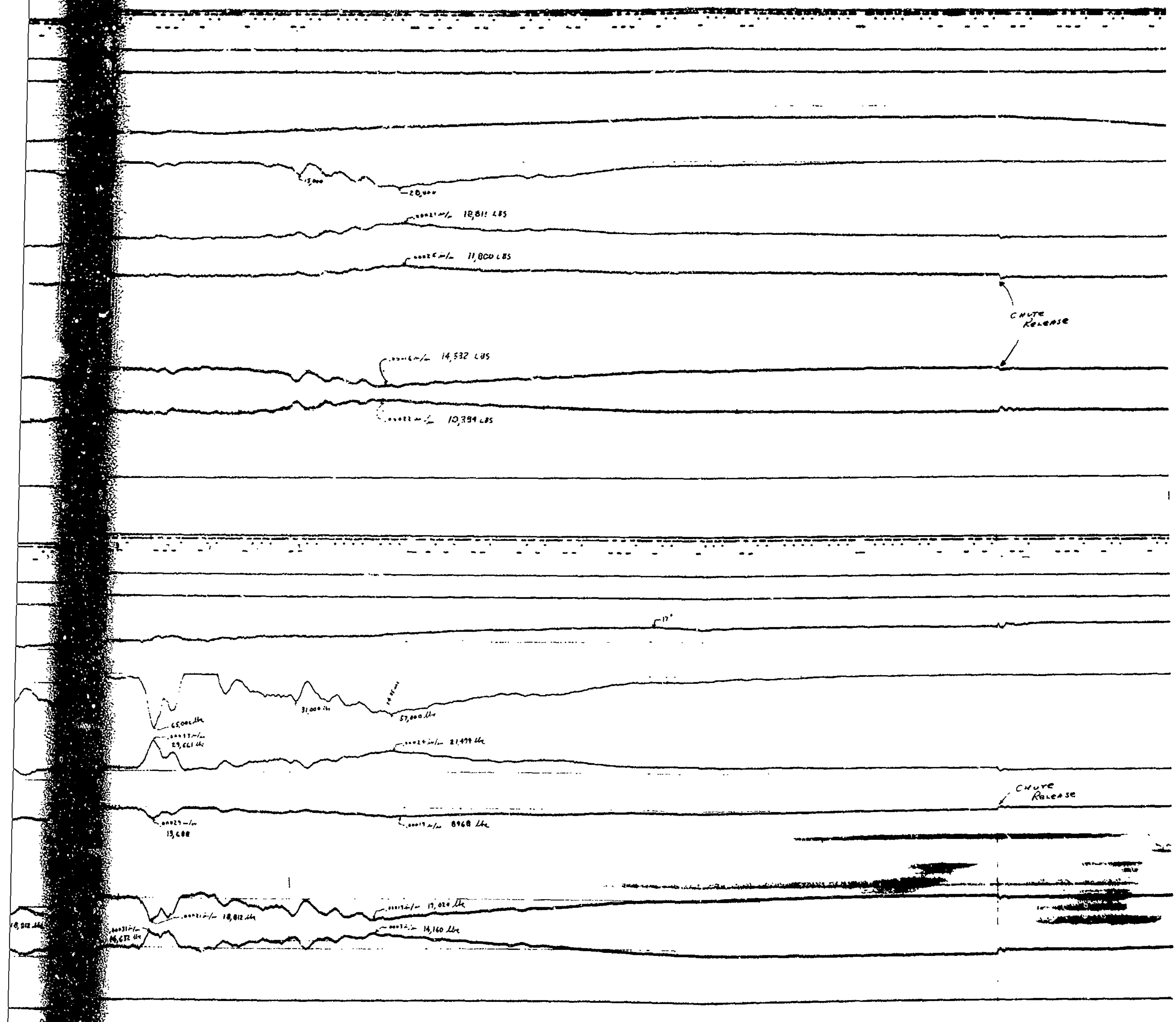

Green Lite
Move.
Angular Move. Fwd Center
Compression Link Fwd Center Right Side
Angular Movement Aft Center
Compression Link Aft Center Right Side
22.659"
Fwd Center Rt Side
Fwd Center Right Side
Angular Move. Fwd Center
Right Side



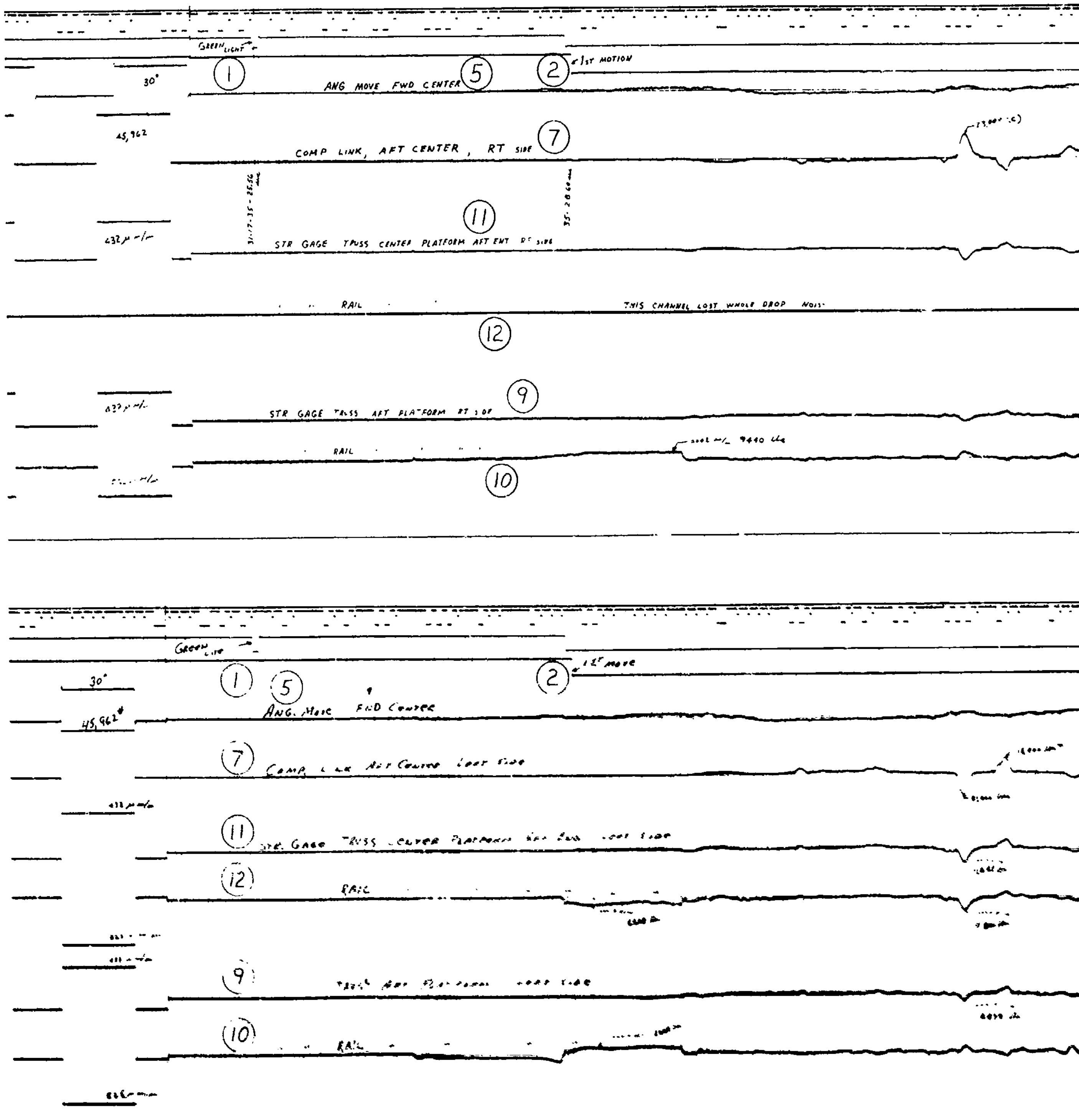
TEST NO. 8 - SHT. NO. 3


GREEN LITE
1
2
1ST MOVE
30°
40,934#
4 ANG. MOVE AFT CENTER RT SIDE
8 COMP. LINK FWD CENTER RT SIDE
15 STR. GAGE TRUSS FWD PLATFORM RT SIDE
16 " " RAIL " " " "
13 " " TRUSS FWD END CENTER PLATFORM
14 " " RAIL " " "

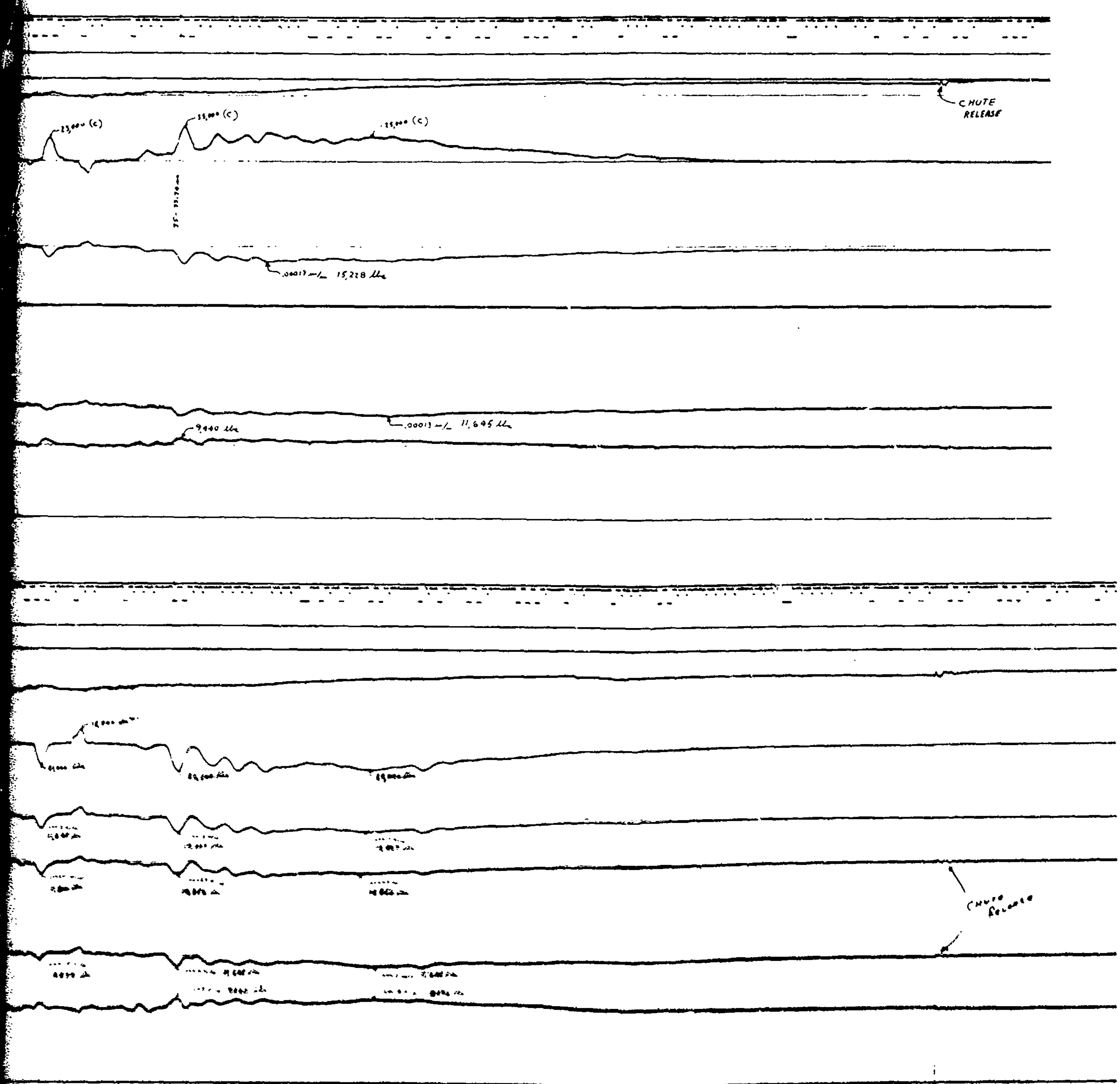

GREEN LITE
1
2
1ST MOVE
30°
51,650#
5 ANG. MOVE FWD CENTER LEFT SIDE
8 COMP LINK " " " "
15 STR. GAGE TRUSS FWD PLATFORM LEFT SIDE
16 " " RAIL " " " " "
13 " " TRUSS FWD END CENTER PLATFORM LEFT SIDE
14 " " RAIL " " " "



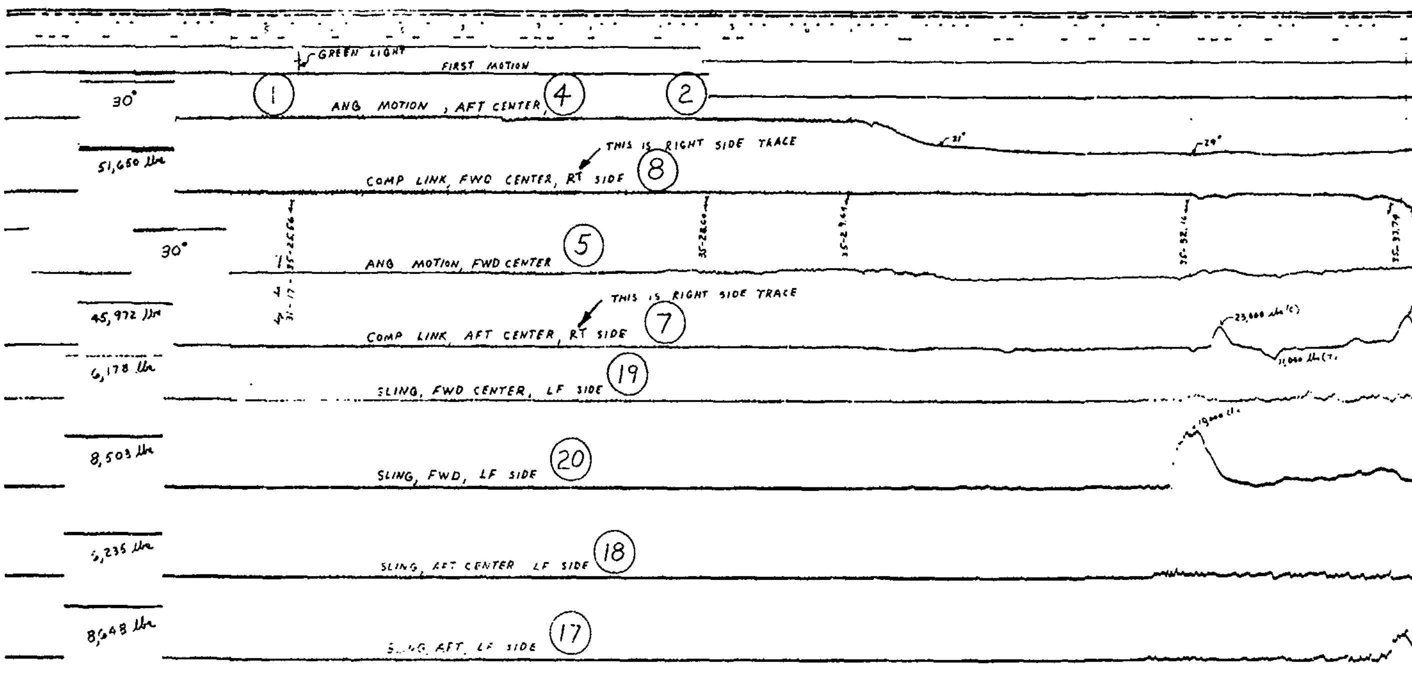
TEST NO. 9 - SHT. NO. 1



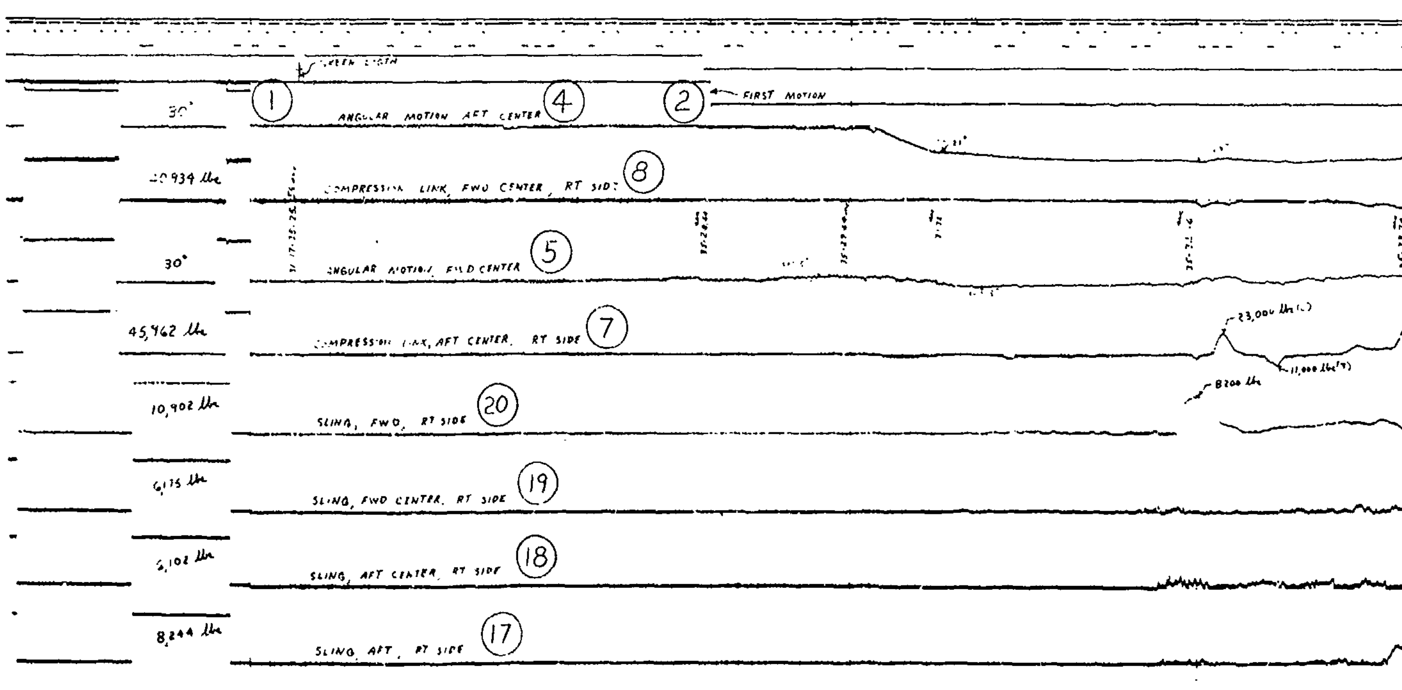
1st MOTION
30°
ANG MOVE FWD CENTER
45,962
COMP LINK, AFT CENTER, RT SIDE
STR GAGE TRUSS CENTER PLATFORM AFT END RT SIDE
RAIL
THIS CHANNEL LOST WHOLE DROP
STR GAGE TRUSS AFT PLATFORM RT SIDE
RAIL
1st MOVE
30°
45,962#
ANG. MOVE FND CENTER
RAIL
RAIL



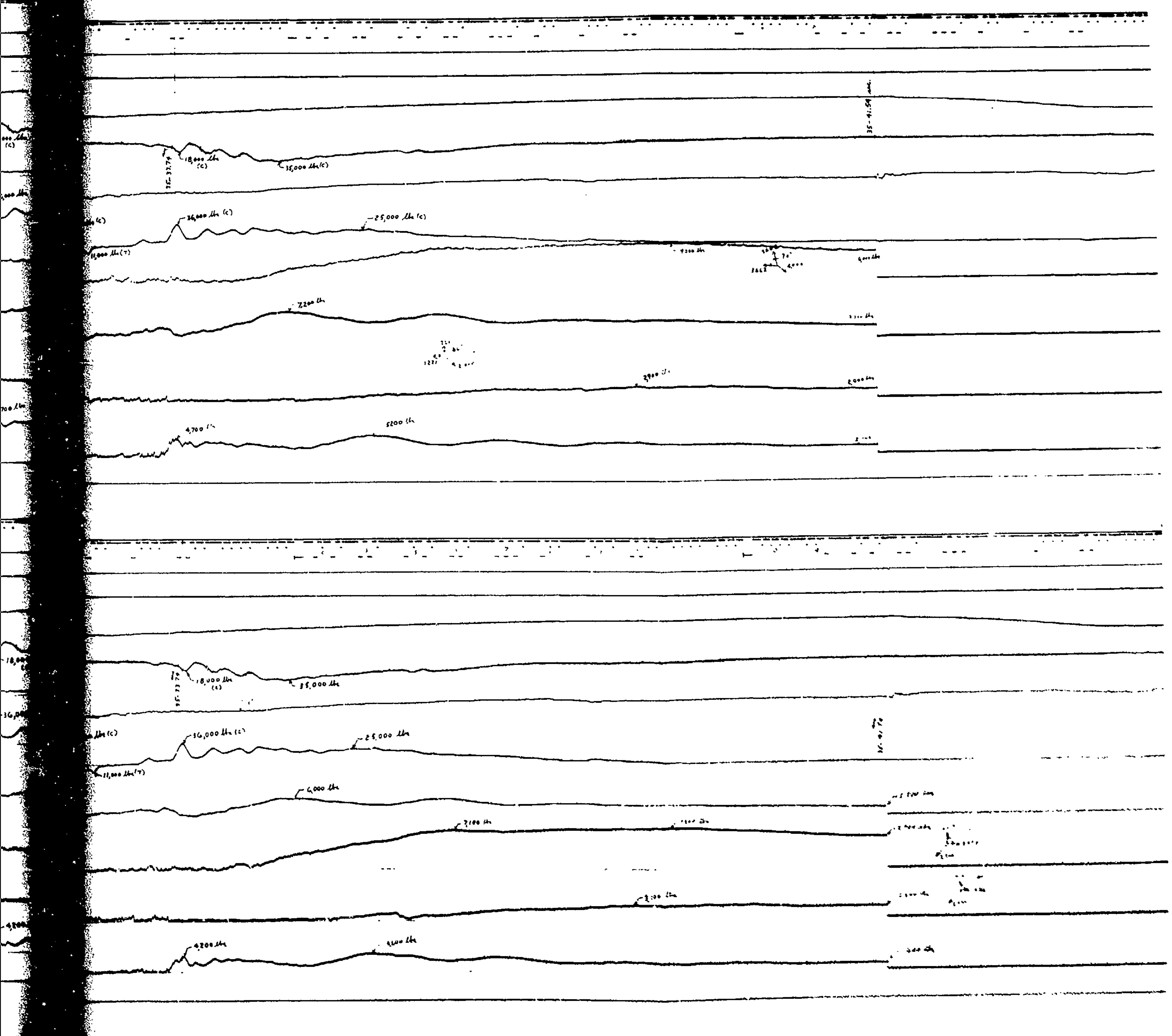
TEST NO. 9 - SHT. NO. 2

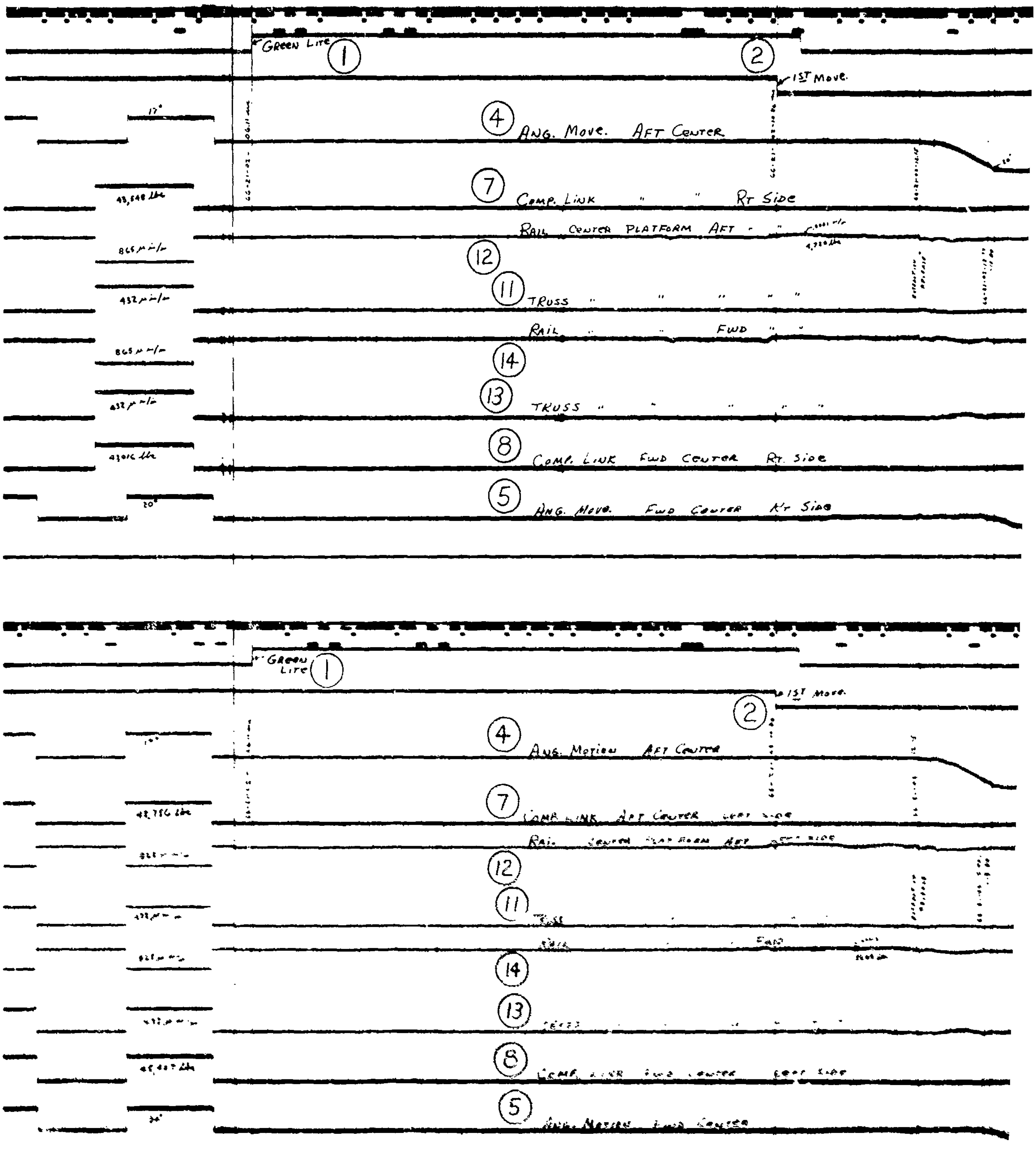


GREEN LIGHT
FIRST MOTION
30°
1
ANG MOTION, AFT CENTER
4
2
THIS IS RIGHT SIDE TRACE
51,650 lbs
COMP LINK, FWD CENTER, RT SIDE
8
30°
ANG MOTION, FWD CENTER
5
THIS IS RIGHT SIDE TRACE
45,972 lbs
COMP LINK, AFT CENTER, RT SIDE
7
6,178 lbs
SLING, FWD CENTER, LF SIDE
19
8,503 lbs
SLING, FWD, LF SIDE
20
SLING, AFT CENTER LF SIDE
18
8,648 lbs
17

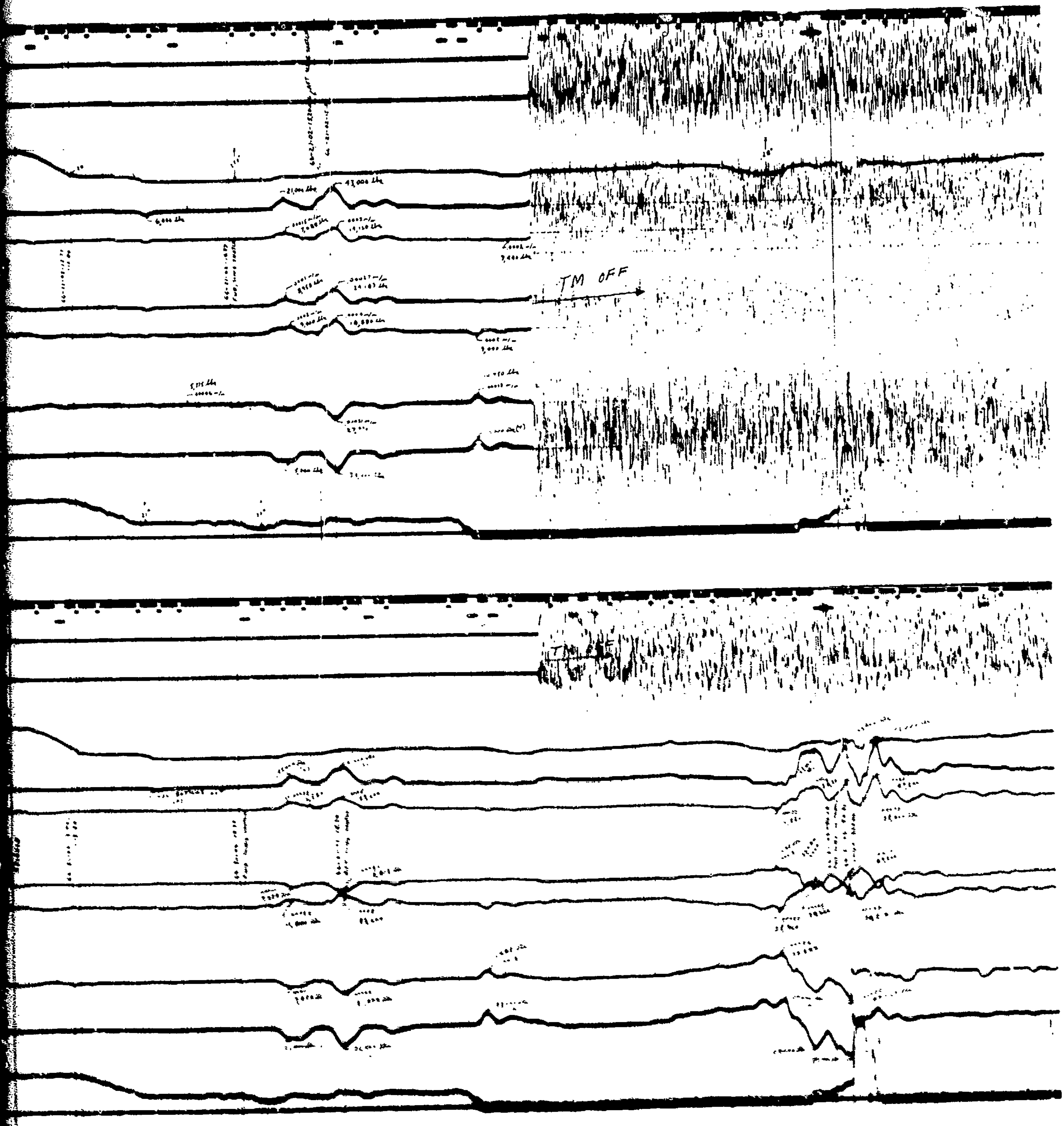


1
4
2
FIRST MOTION
30°
ANGULAR MOTION AFT CENTER
COMPRESSION LINK, FWD CENTER, RT SIDE
8
30°
ANGULAR MOTION FWD CENTER
5
45,462 lbs
AFT CENTER, RT SIDE
7
23,000 lbs
11,000 lbs
8200 lbs
10,902 lbs
SLING, FWD, RT SIDE
20
SLING, FWD CENTER, RT SIDE
19
SLING, AFT CENTER, RT SIDE
18
8,244 lbs
SLING, AFT, RT SIDE
17

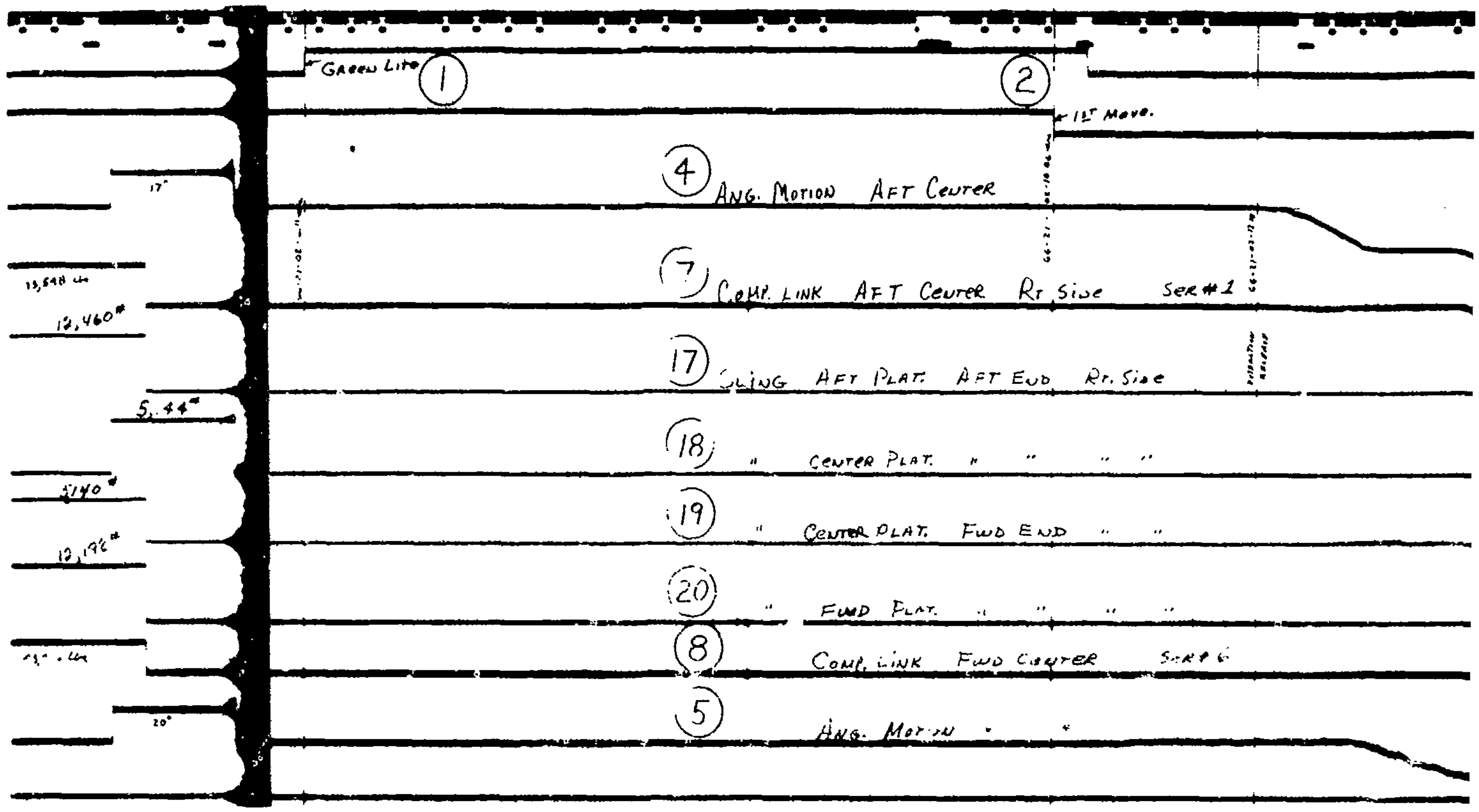


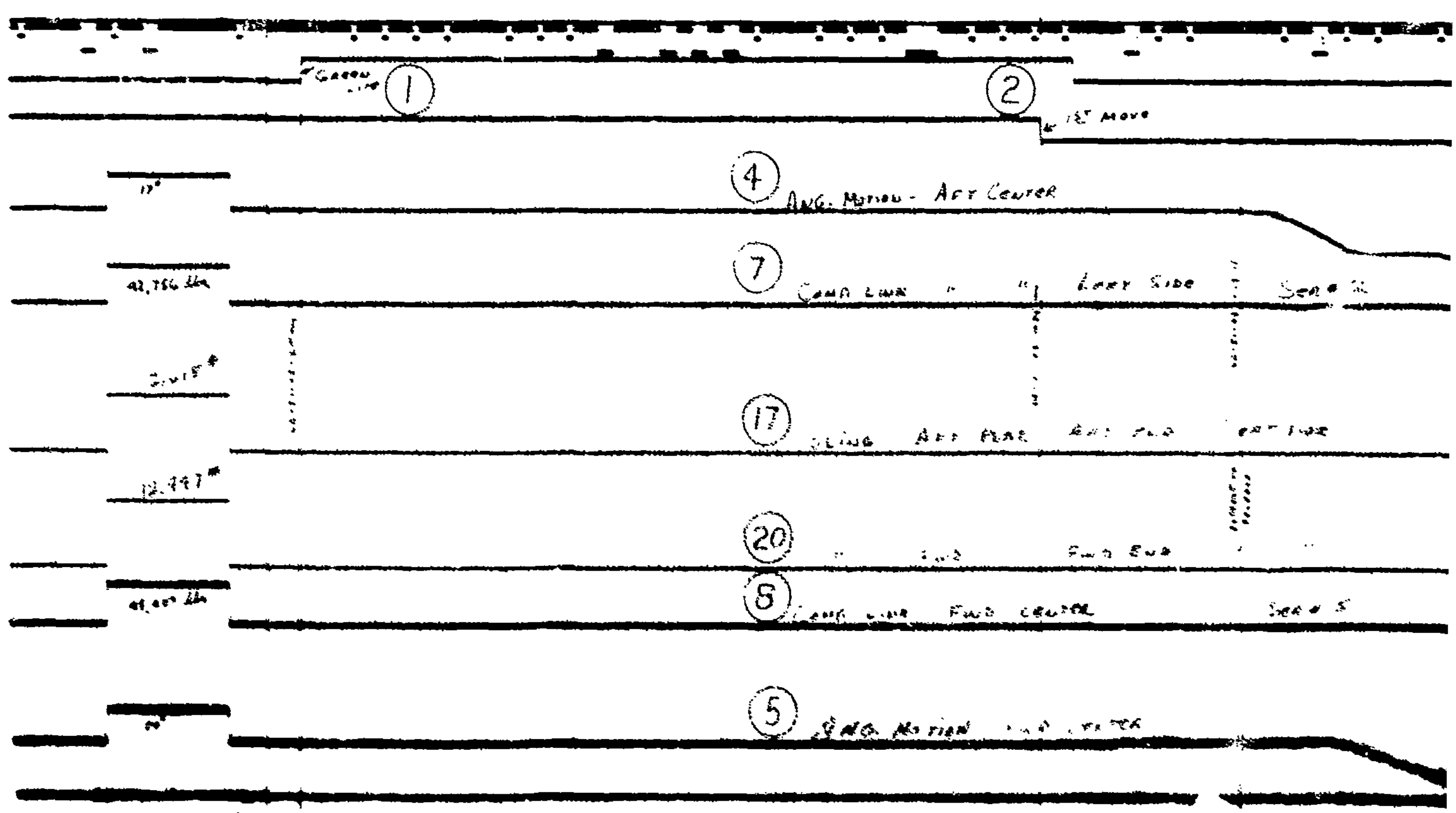


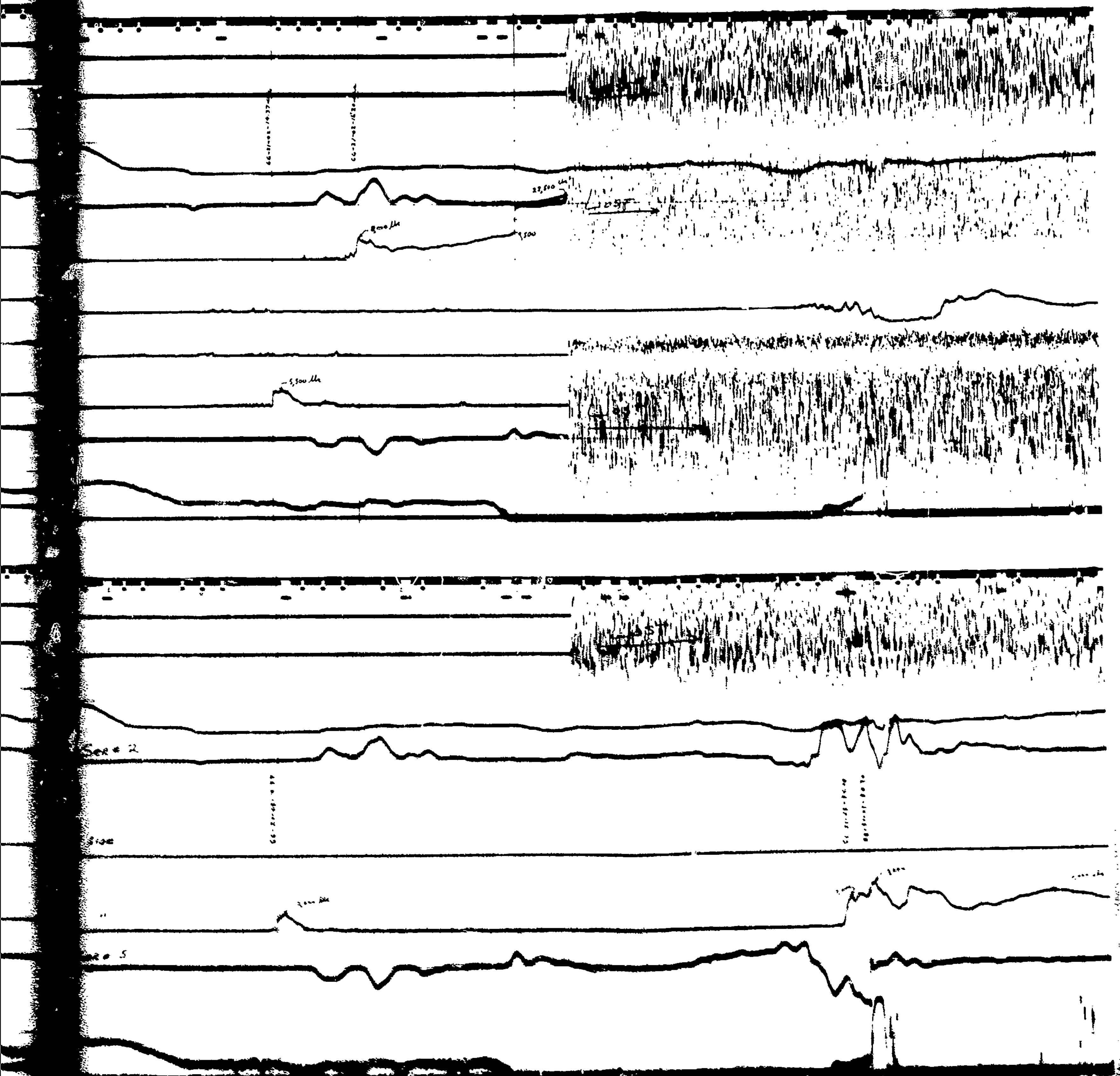
Green Lite
1
2
1ST Move.
4
Ang. Move. Aft Center
7
Comp. Link " " Rt Side
Rail Center Platform Aft
12
11
Truss
Rail Fwd
14
13
Truss
8
Comp. Link Fwd Center Rt. Side
5
Ang. Move. Fwd Center Rt Side
Green Lite
1
1ST Move
2
4
Ang. Motion Aft Center
7
12
11
14
13
8
5



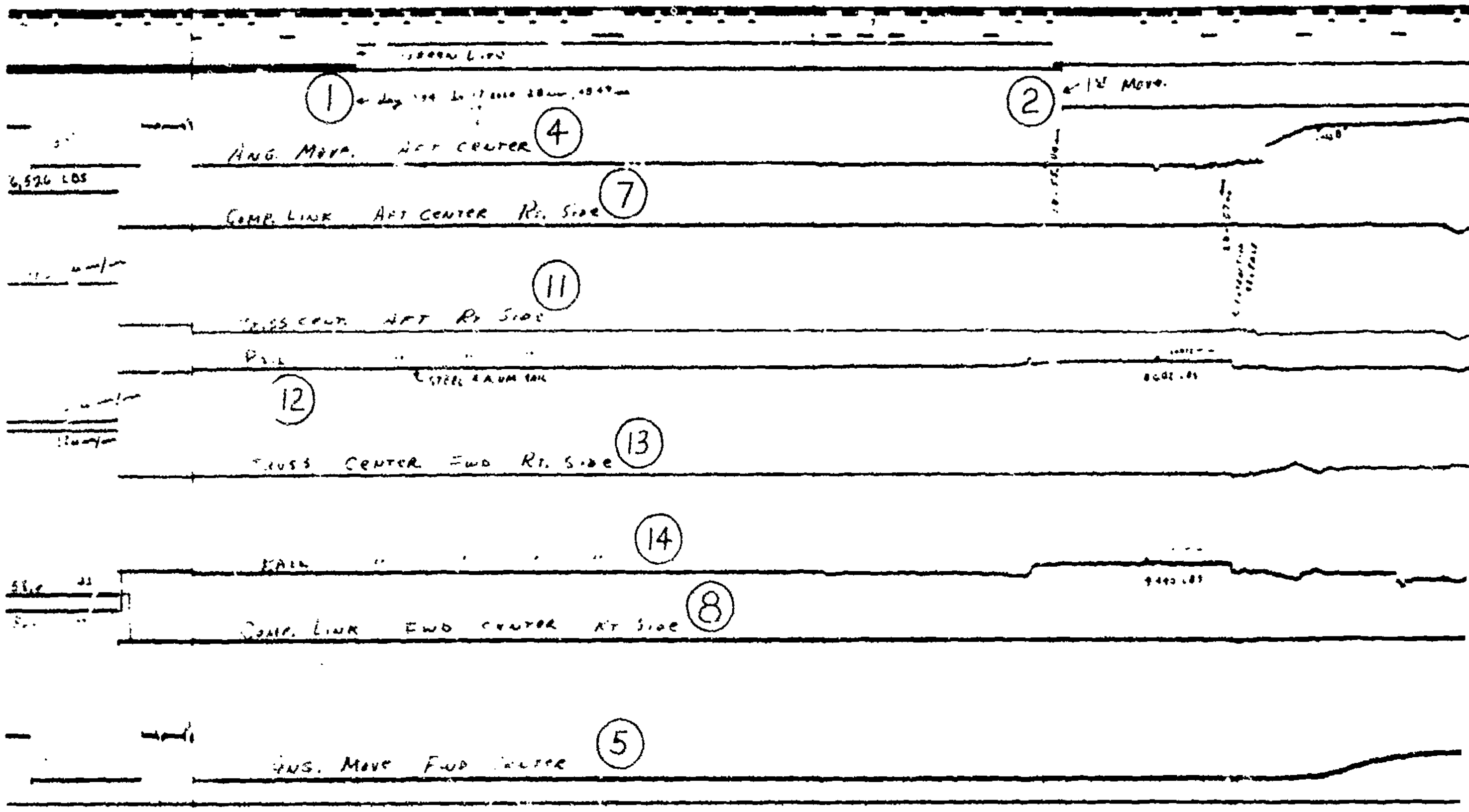
TEST NO. 10 - SHT. NO. 1


Green Lite
1
2
1st Move.
17°
4 Ang. Motion Aft Center
12,460#
7 Comp. Link Aft Center Rt Side Ser #1
17 Sling Aft Plat. Aft End Rt. Side
18 " Center Plat. " " " "
5140#
19 " Center Plat. Fwd End " "
20 " Fwd Plat. " " " "
8 Comp. Link Fwd Center
20°
5 Ang. Motion " "

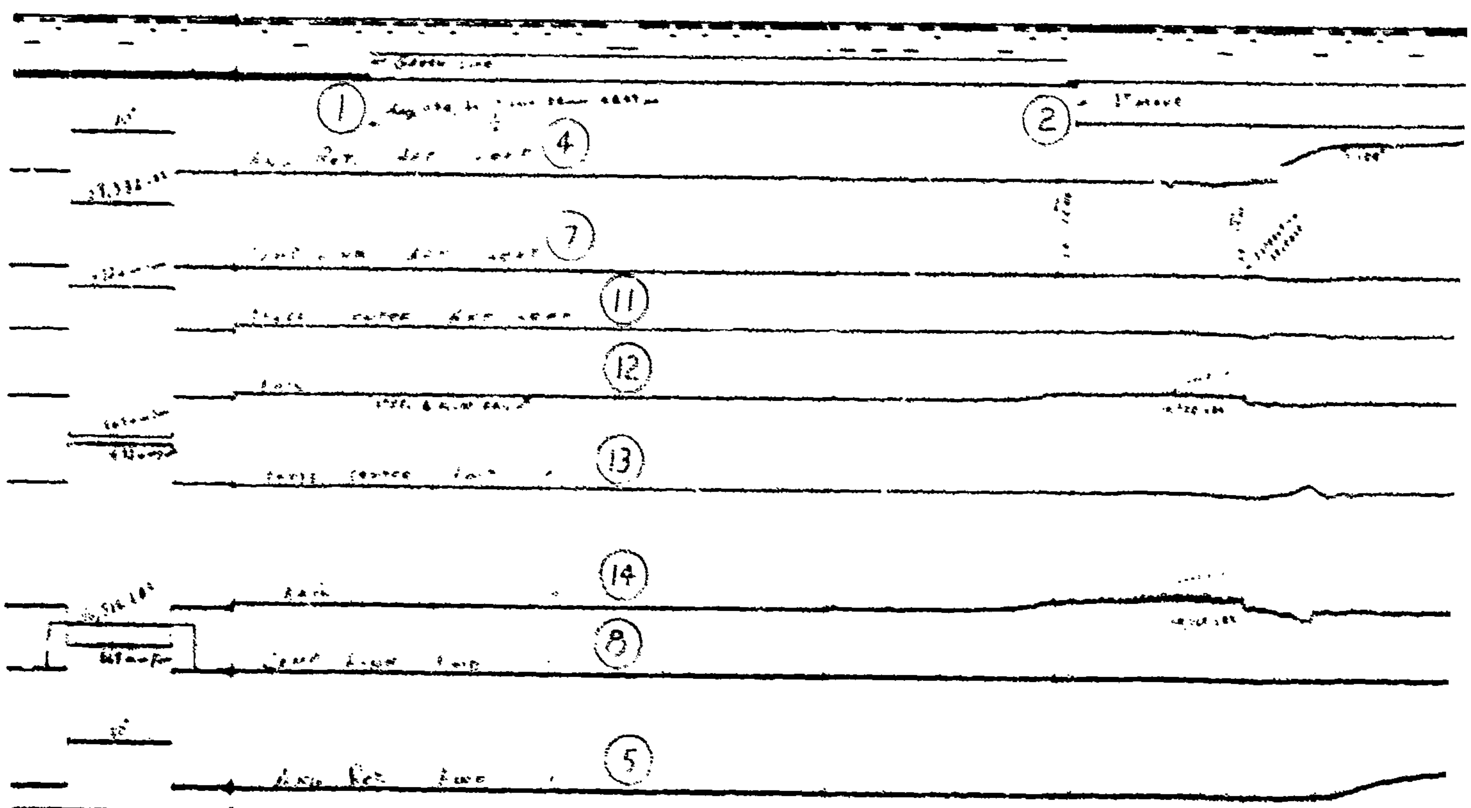

Green Lite
1
2
1st Move
17°
4 Ang. Motion - Aft Center
7 Comp. Link " " Left Side
17 Sling Aft Plat.
20
8 Comp. Link Fwd Center
5 Ang. Motion



TEST NO. 10 - SHT. NO. 2

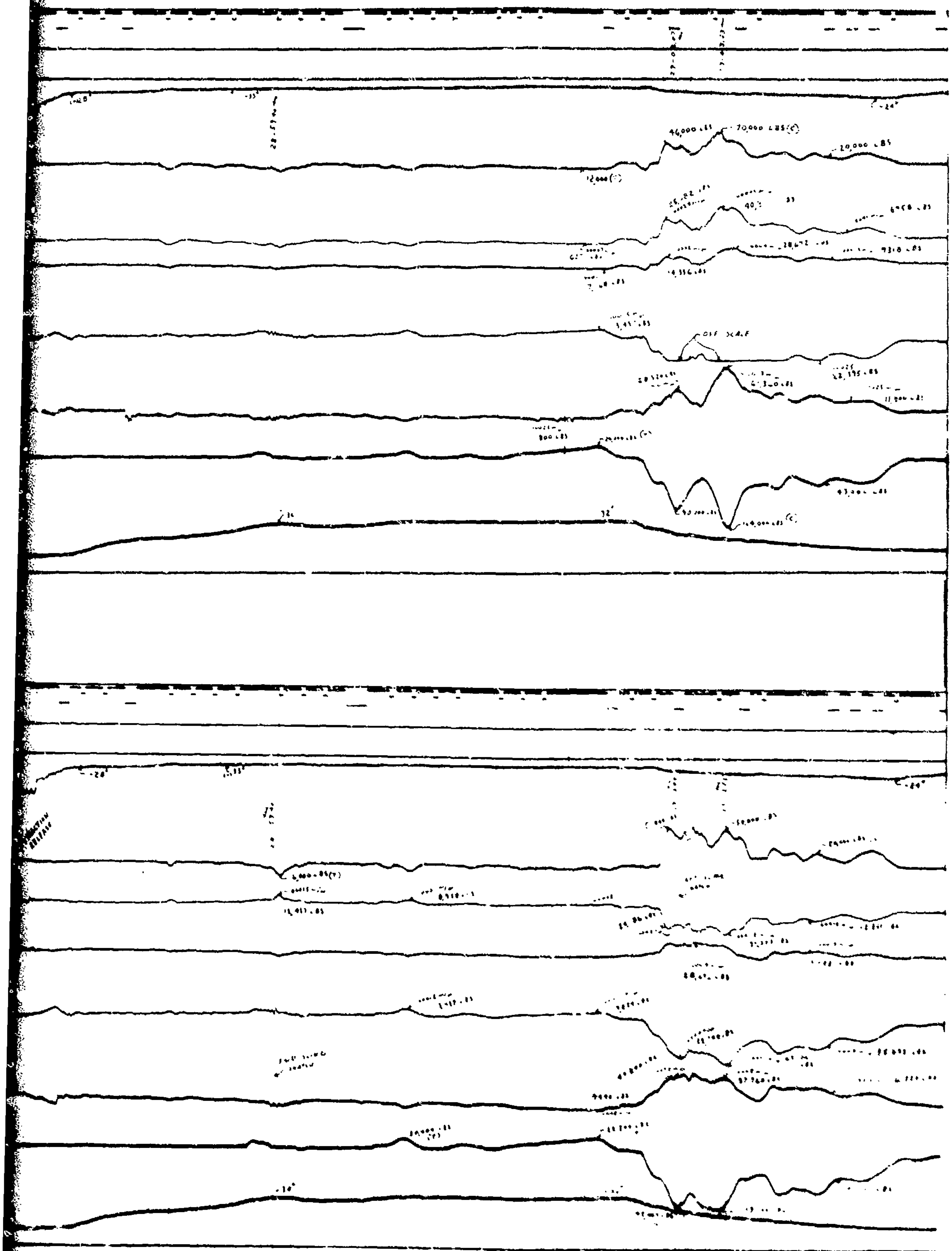


1
2
1st Move
Ang. Move. Aft Center
4
6,526 LBS
Comp. Link Aft Center Rt. Side
7
11
Aft Rt. Side
12
Truss Center Fwd Rt. Side
13
Rail
14
Comp. Link Fwd Center Rt Side
8
Ang. Move Fwd Center
5

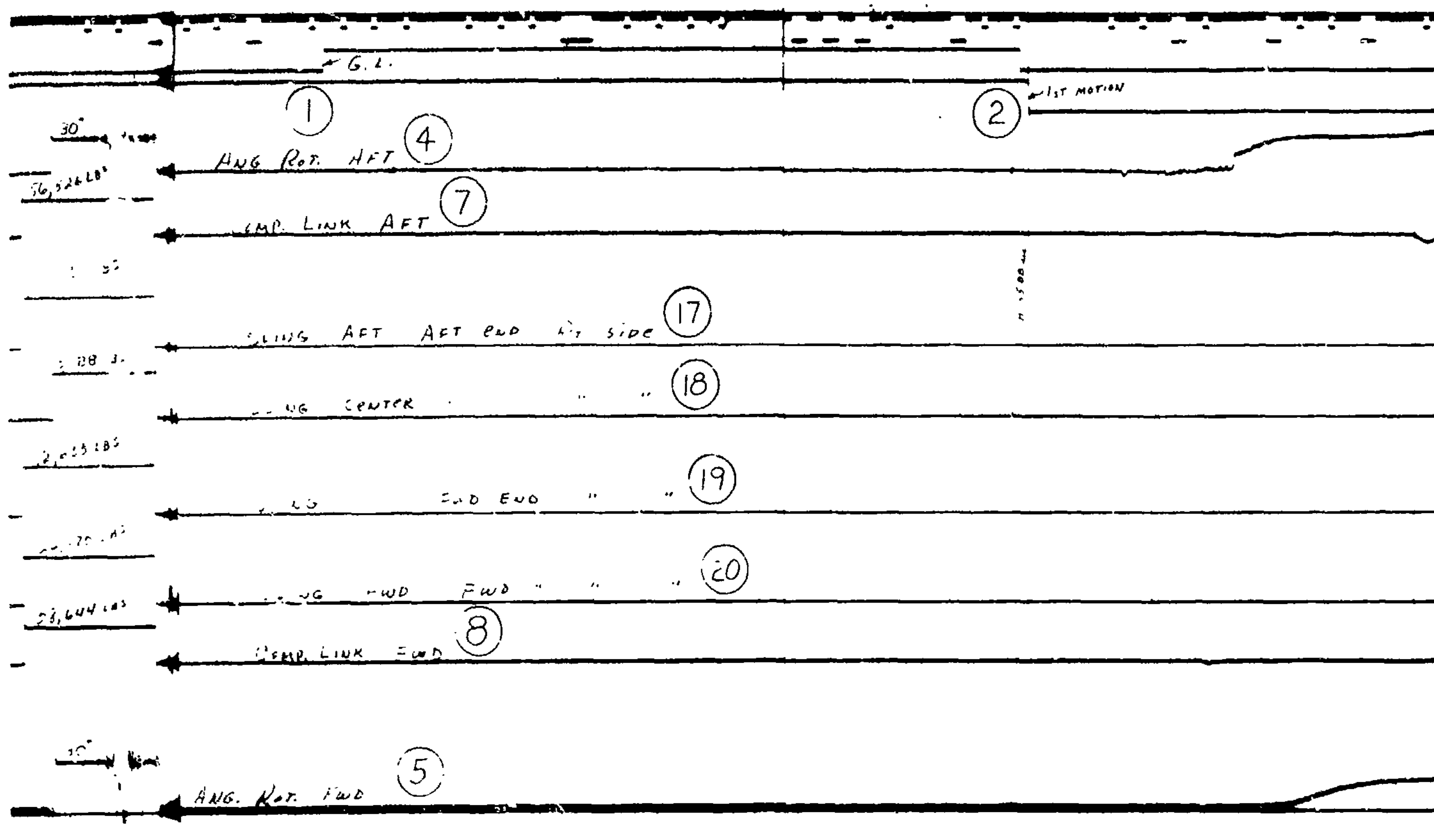


1
2
1st Move
4
7
11
12
13
Rail
14
8
5

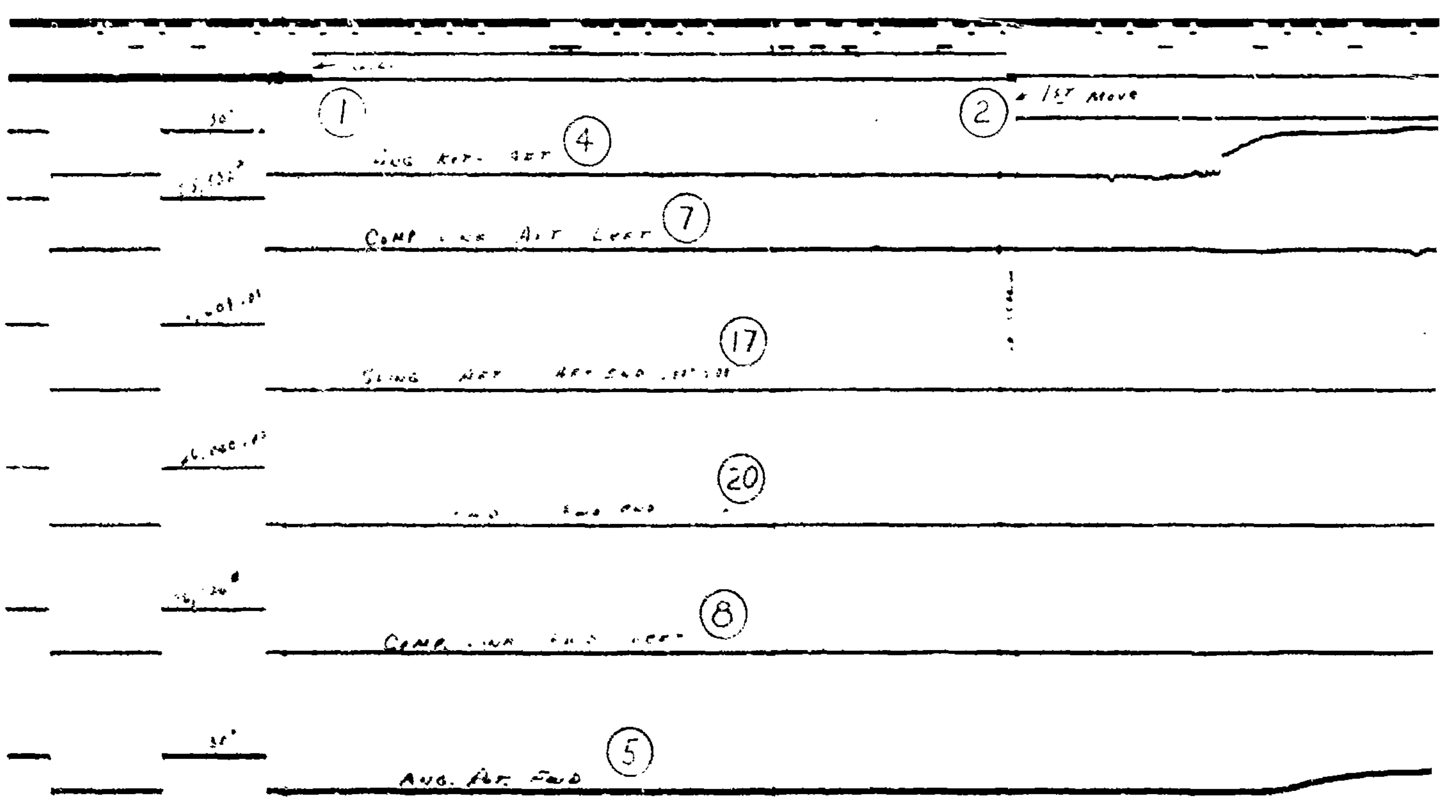
1



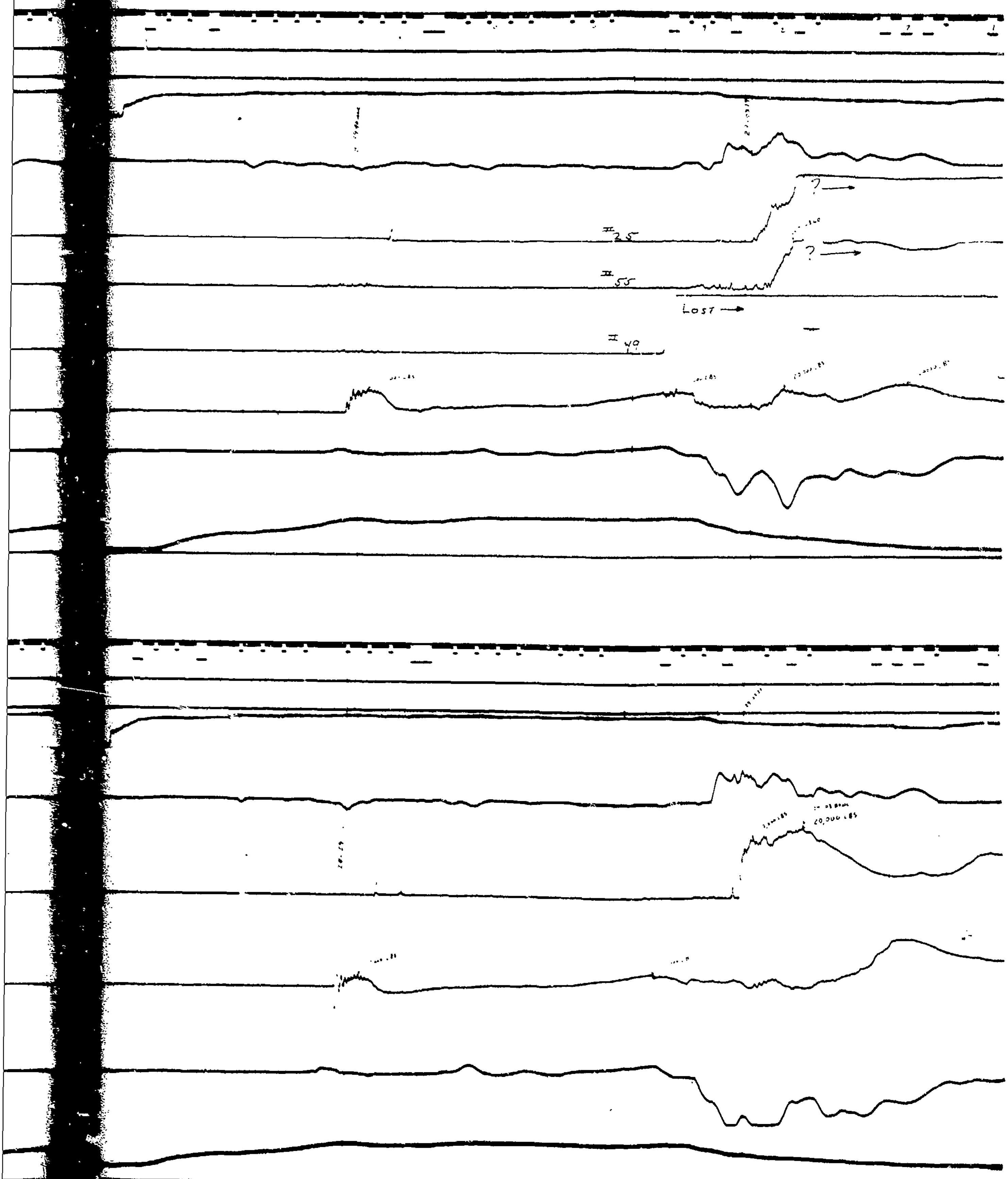
TEST NO. 11 - SHT. NO. 1

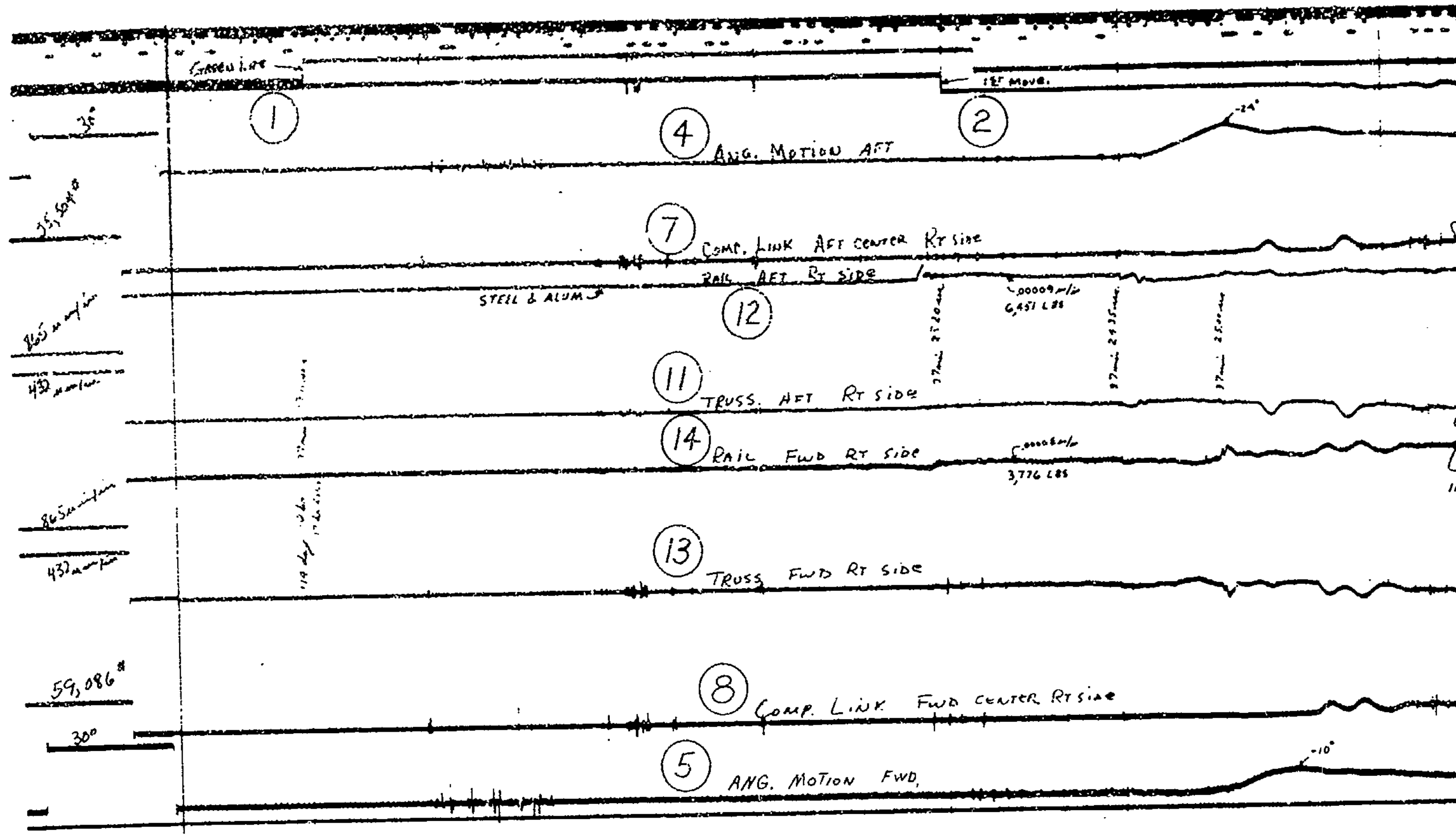


G.L.
1
2
1ST MOTION
30°
ANG ROT. AFT
4
COMP. LINK AFT
7
SLING AFT AFT END
17
CENTER
18
19
FWD END
20
FWD
COMP. LINK FWD
8
ANG. ROT. FWD
5

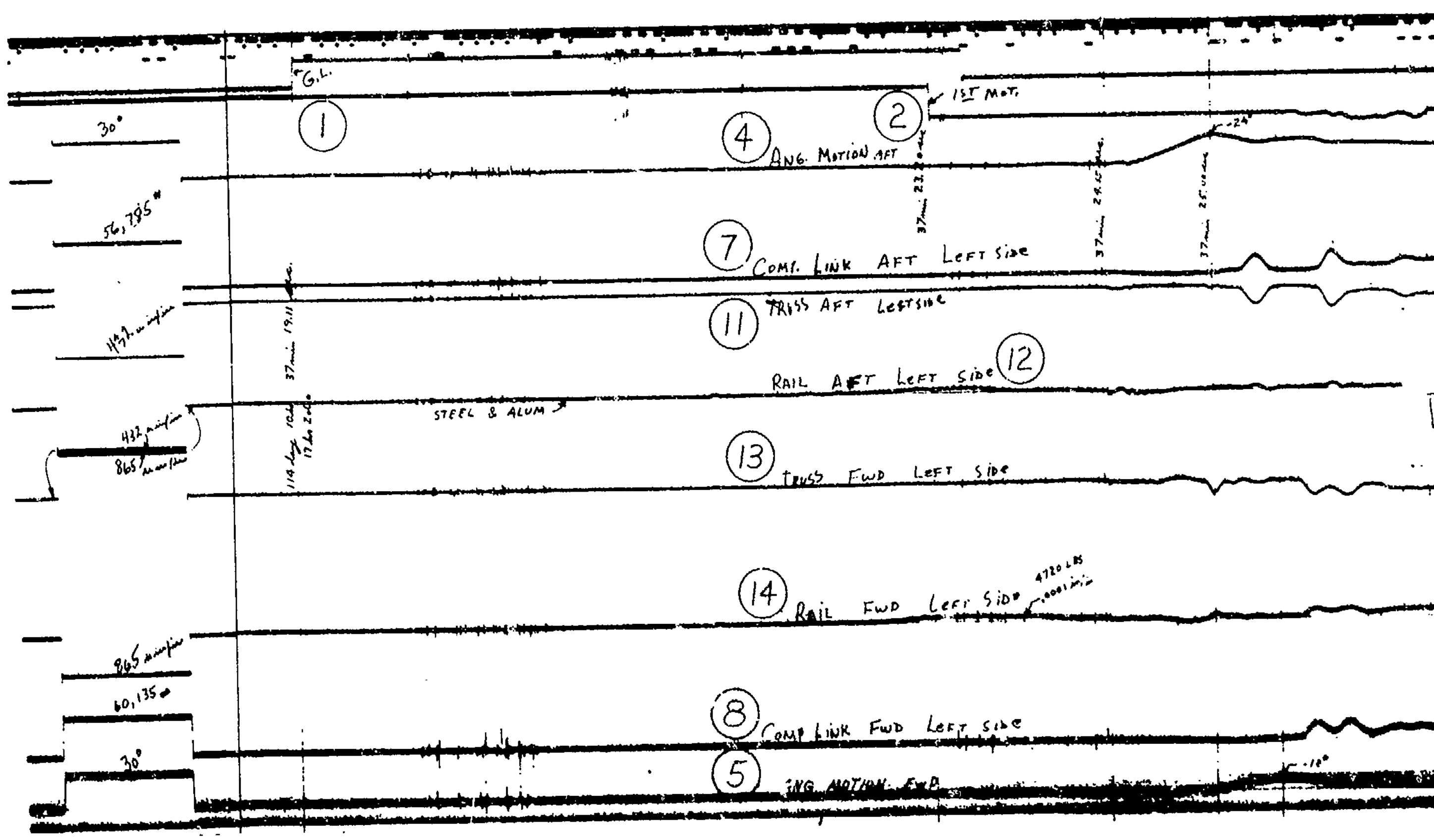


1
2
1ST MOVE
30°
4
COMP
AFT LEFT
7
SLING
17
20
8
COMP.
35°
ANG. ROT. FWD
5

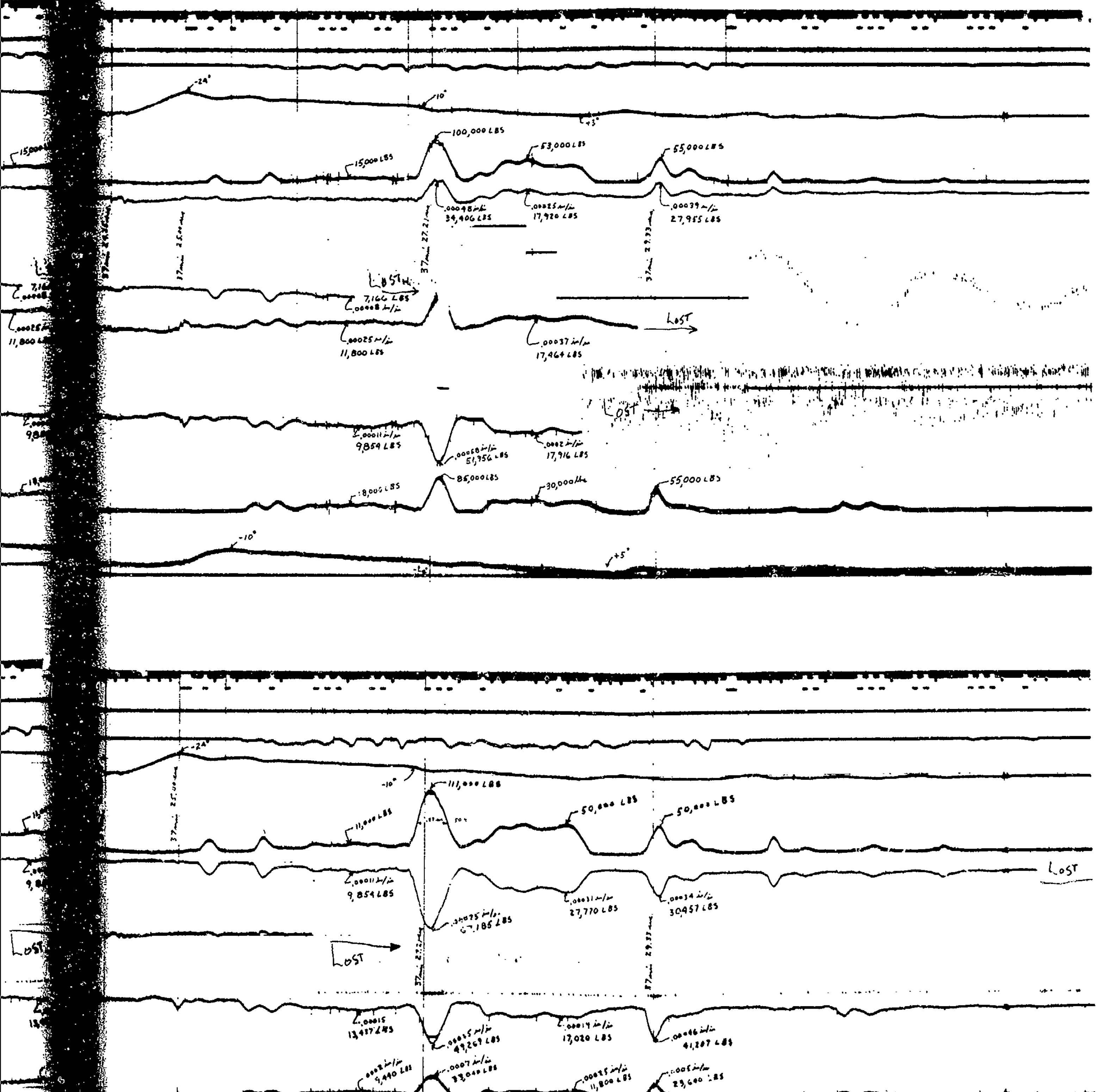

?
#25
?
#55
LOST
#40
20,000 LBS



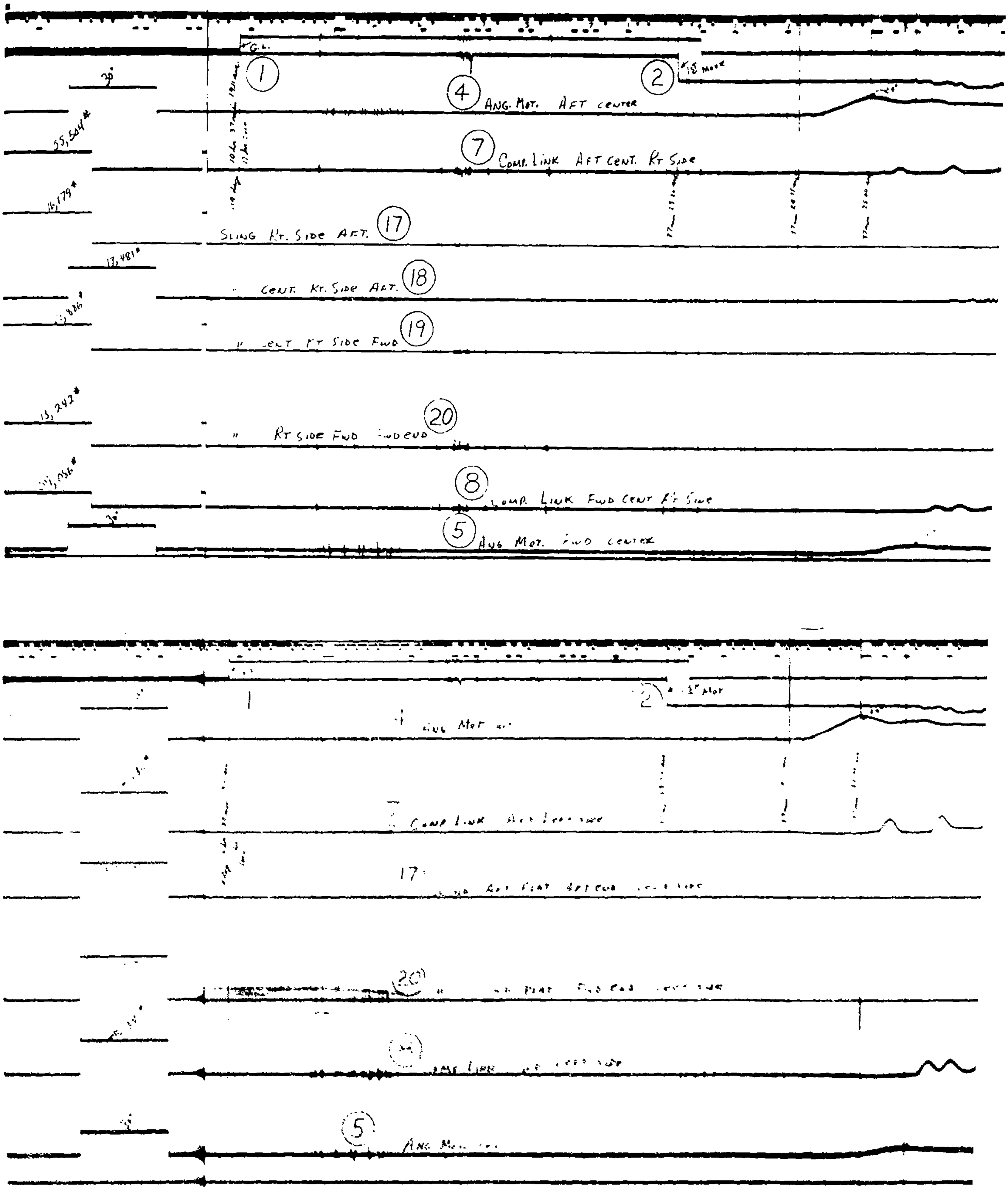
GREEN LITE
1ST MOVE
1
2
4 ANG. MOTION AFT
-24°
30°
7 COMP. LINK AFT CENTER RT SIDE
RAIL AFT RT SIDE
STEEL & ALUM
12
.00009 in/in
6,451 LBS
865 μ in/in
432 μ in/in
11 TRUSS AFT RT SIDE
14 RAIL FWD RT SIDE
3,776 LBS
865 μ in/in
432 μ in/in
13 TRUSS FWD RT SIDE
59,086#
30°
8 COMP. LINK FWD CENTER RT SIDE
5 ANG. MOTION FWD.
-10°



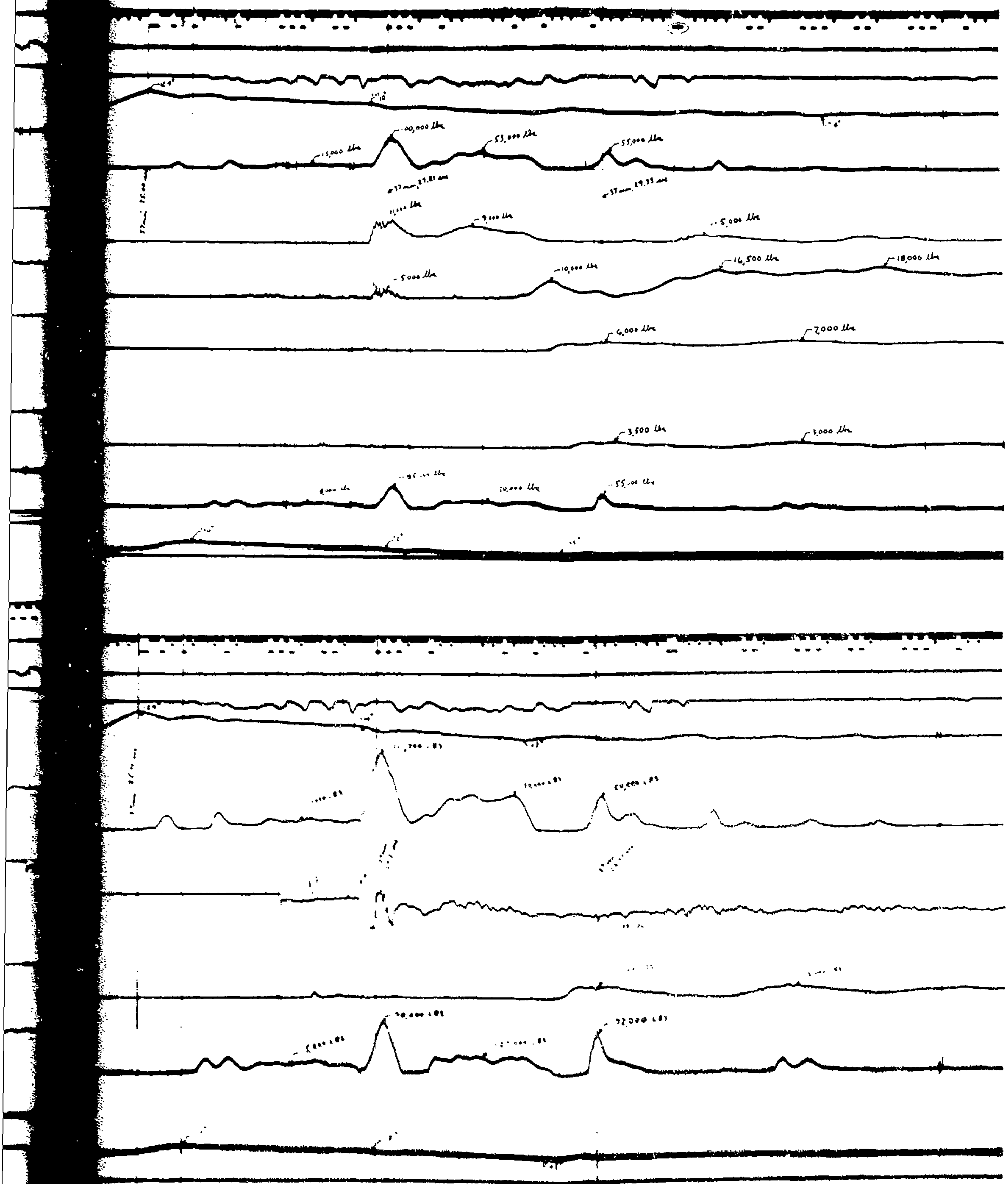
G.L.
1ST MOT.
1
2
4 ANG. MOTION AFT
-24°
30°
56,785#
7 COMP. LINK AFT LEFT SIDE
11 TRUSS AFT LEFT SIDE
432 μ in/in
RAIL AFT LEFT SIDE 12
STEEL & ALUM
432 μ in/in
865 μ in/in
13 TRUSS FWD LEFT SIDE
14 RAIL FWD LEFT SIDE
4720 LBS
.0001 in/in
865 μ in/in
60,135#
30°
8 COMP LINK FWD LEFT SIDE
5 ANG MOTION FWD
-10°



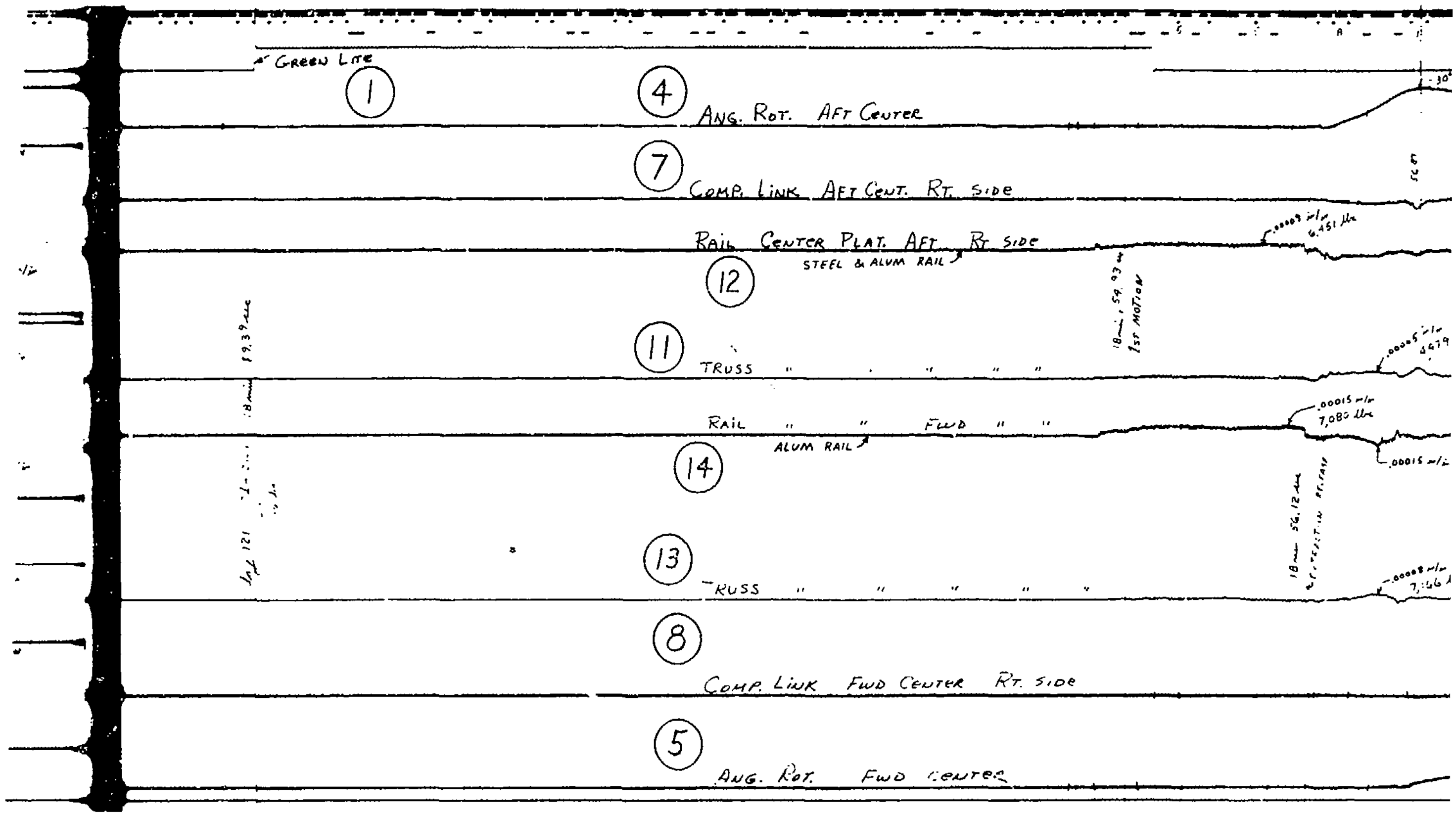
TEST NO. 13 - SHT. NO. 1

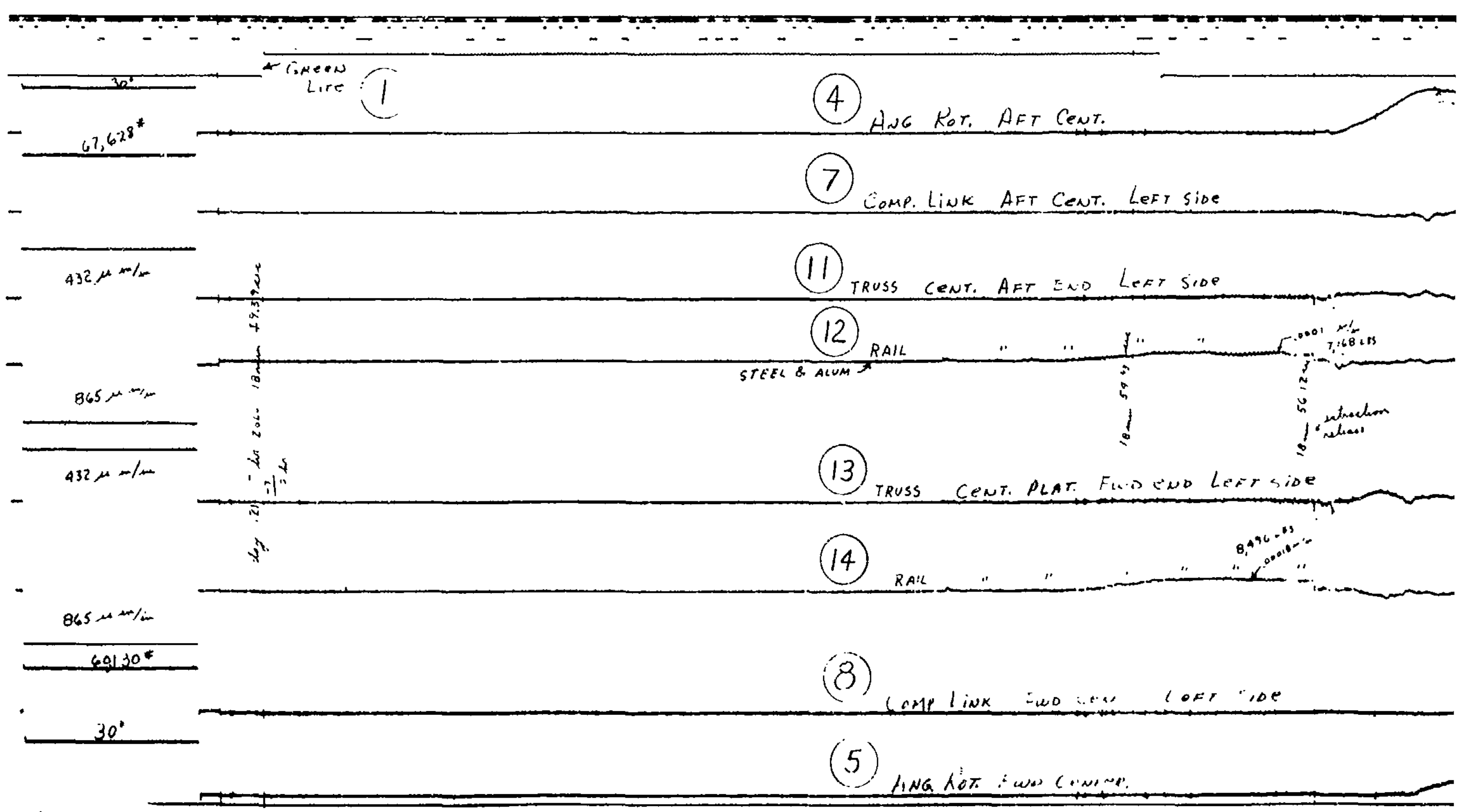


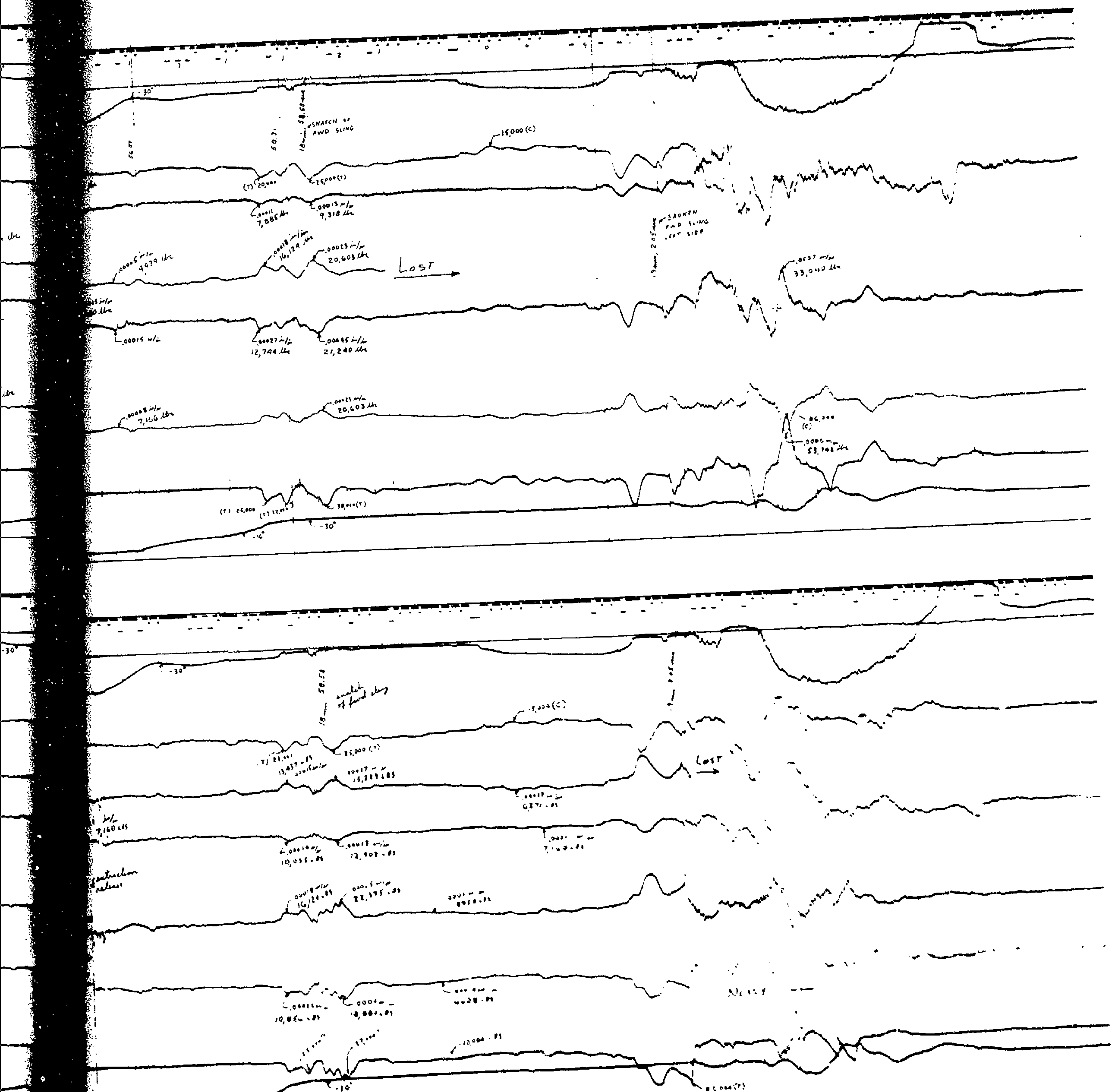
1
2
4
ANG. MOT. AFT CENTER
7
COMP. LINK AFT CENT. RT SIDE
SLING RT. SIDE AFT.
17
CENT. RT. SIDE AFT.
18
19
20
RT SIDE FWD
8
COMP. LINK FWD CENT RT SIDE
5
ANG MOT. FWD CENTER



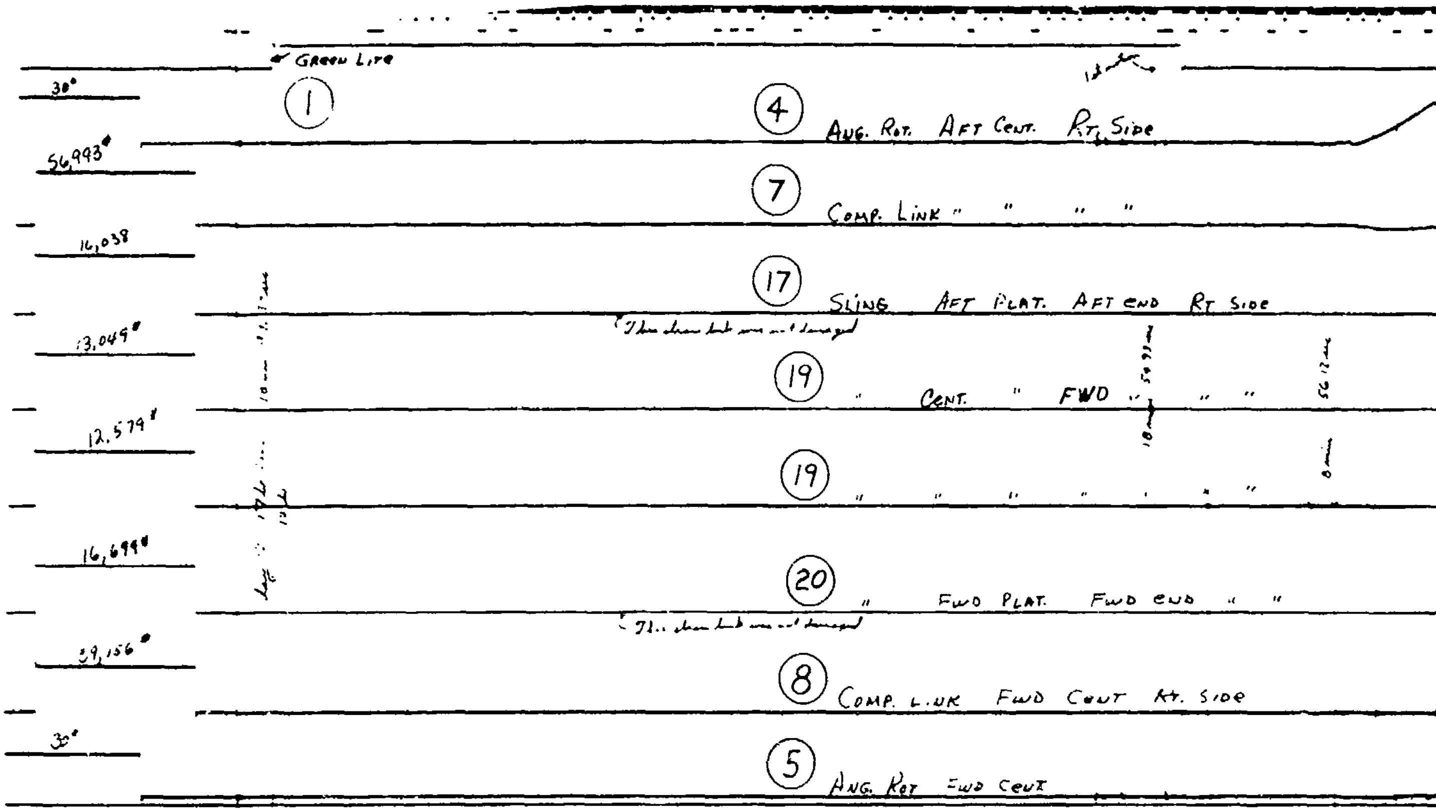
TEST NO. 13 - SHT. NO. 2


GREEN LITE
1
4 ANG. ROT. AFT CENTER
7 COMP. LINK AFT CENT. RT. SIDE
RAIL CENTER PLAT. AFT RT. SIDE
STEEL & ALUM RAIL
12
11 TRUSS
RAIL FWD
ALUM RAIL
14
13 TRUSS
8 COMP. LINK FWD CENTER RT. SIDE
5 ANG. ROT. FWD CENTER
1ST MOTION

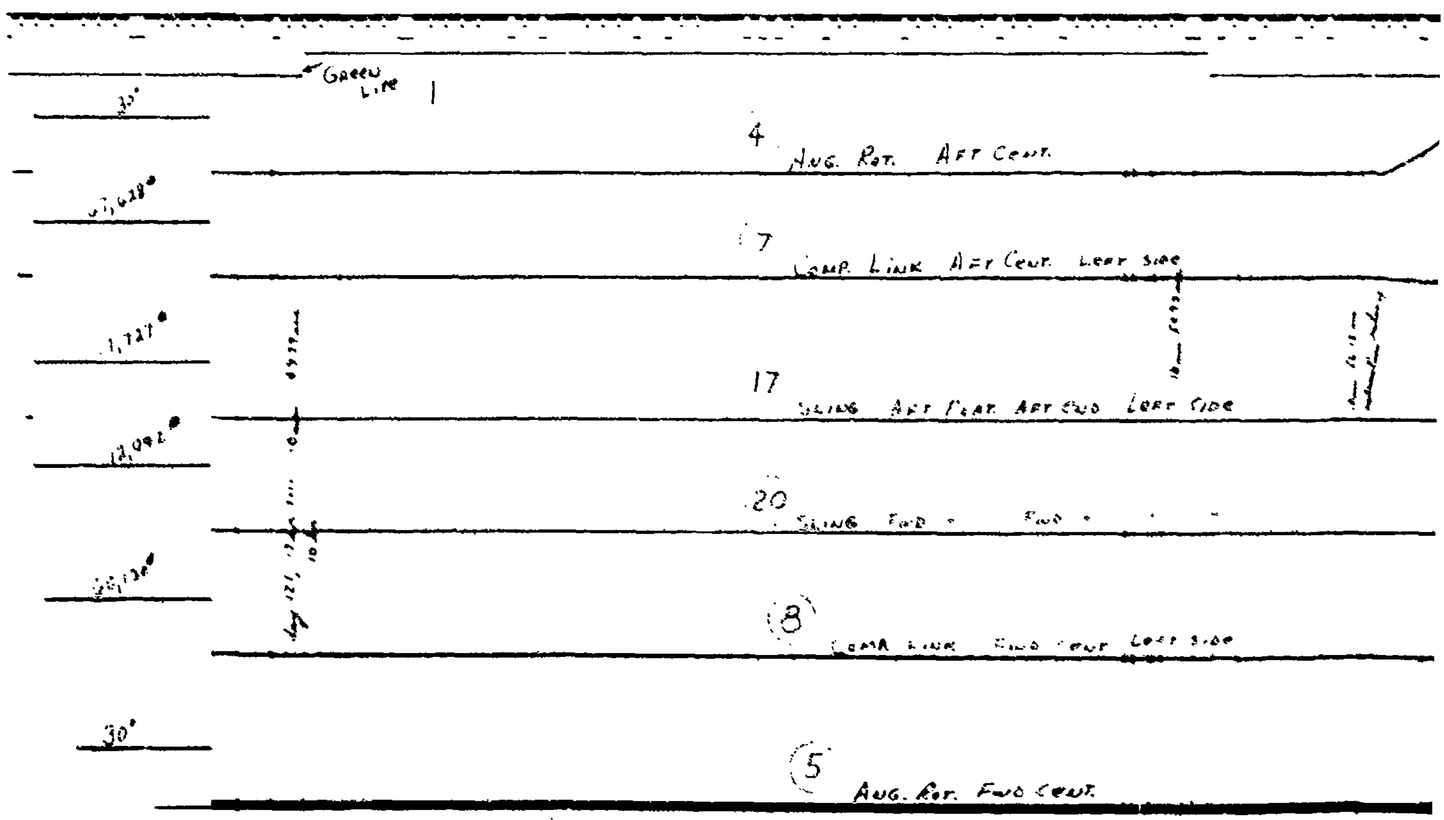

GREEN LITE
1
30°
67,628#
432 μ in/in
865 μ in/in
432 μ in/in
865 μ in/in
69130#
30°
4 ANG ROT. AFT CENT.
7 COMP. LINK AFT CENT. LEFT SIDE
11 TRUSS CENT. AFT END LEFT SIDE
12 RAIL
STEEL & ALUM
13 TRUSS CENT. PLAT. FWD END LEFT SIDE
14 RAIL
8 COMP LINK
5 ANG ROT.



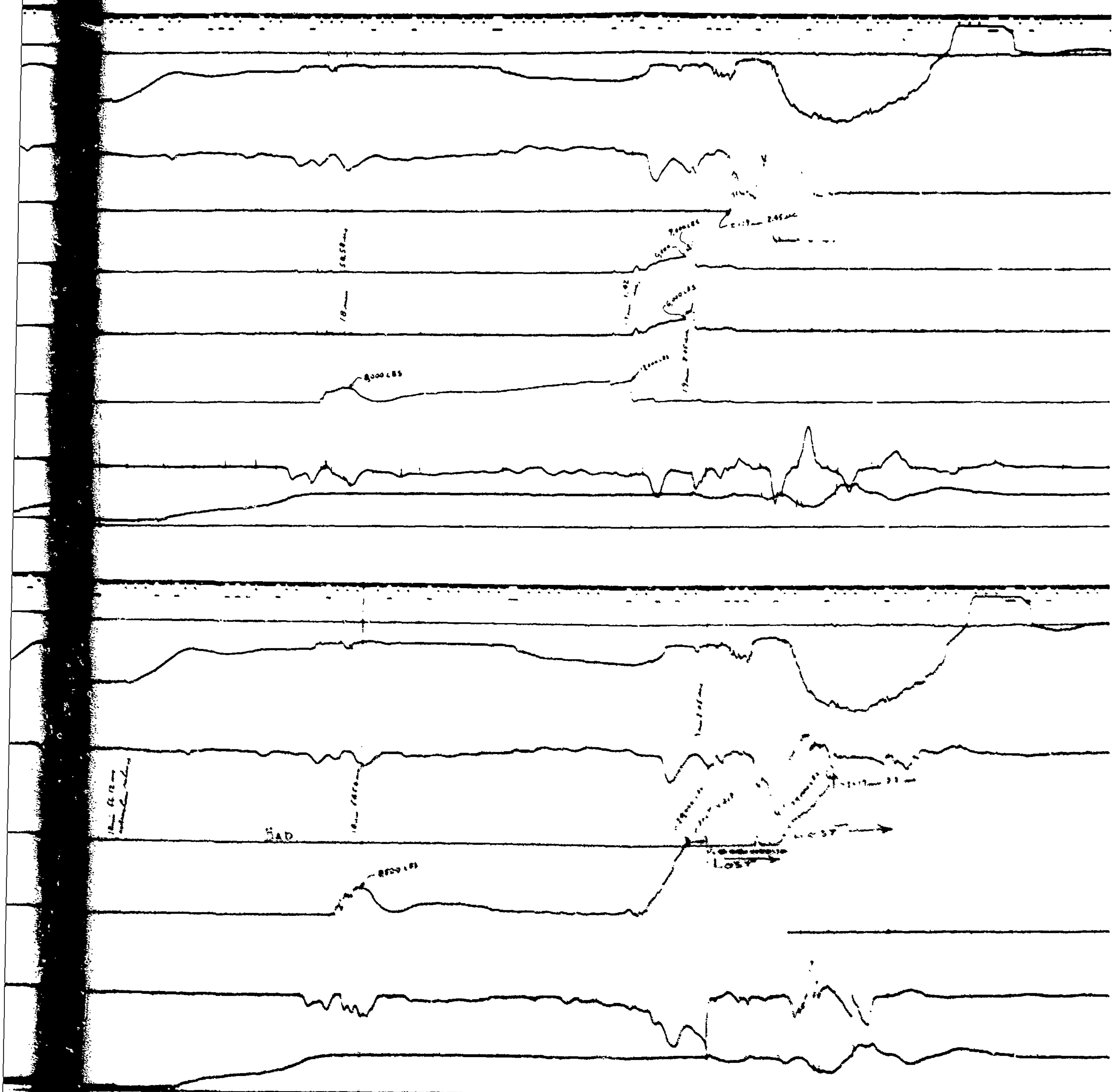
TEST NO. 14 - SHT. NO. 1



GREEN LINE
30°
56,993#
16,038
13,049#
12,579#
16,699#
39,156#
30°
1
4 AUG. ROT. AFT CENT. RT. SIDE
7 COMP. LINK " " " "
17 SLING AFT PLAT. AFT END RT SIDE
19 " CENT. " FWD " " "
19
20 " FWD PLAT. FWD END " "
8 COMP. LINK FWD CENT RT. SIDE
5 AUG. ROT FWD CENT



GREEN LINE
30°
1,727#
12,092#
30°
1
4 AUG. ROT. AFT CENT.
7 COMP. LINK AFT CENT. LEFT SIDE
17 SLING AFT PLAT. AFT END LEFT SIDE
20 SLING FWD " FWD "
8 COMP. LINK FWD CENT LEFT SIDE
5 AUG. ROT. FWD CENT.



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